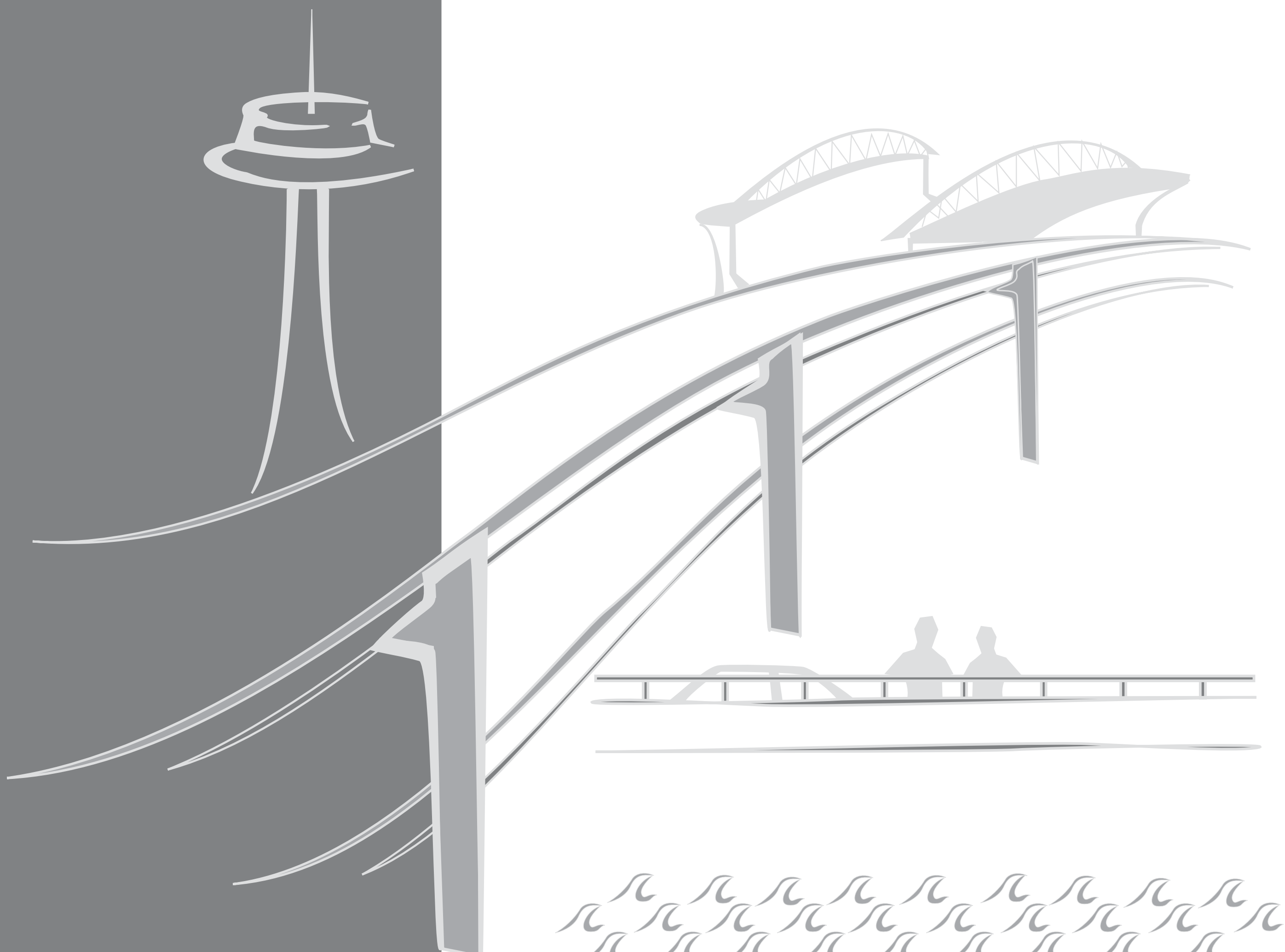
SR 99: ALASKAN WAY VIADUCT & SEAWALL REPLACEMENT PROJECT

Draft Environmental Impact Statement
Appendix R
Fisheries, Wildlife, and Habitat Discipline Report



MARCH 2004

Submitted by:
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U.S. Department of Transportation Federal Highway Administration

Washington State Department of Transportation

City of Seattle

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SR 99: ALASKAN WAY VIADUCT & SEAWALL REPLACEMENT PROJECT

Draft EIS
Fisheries, Wildlife, and Habitat Discipline Report

AGREEMENT NO. Y-7888

FHWA-WA-EIS-04-01-D

Submitted to:

Washington State Department of Transportation
Alaskan Way Viaduct and Seawall Replacement Project Office
999 Third Avenue, Suite 2424
Seattle, WA 98104

The SR 99: Alaskan Way Viaduct & Seawall Replacement Project is a joint effort between the Washington State Department of Transportation (WSDOT), the City of Seattle, and the Federal Highway Administration (FHWA). To conduct this project, WSDOT contracted with:

Parsons Brinckerhoff Quade & Douglas, Inc.

999 Third Avenue, Suite 2200
Seattle, WA 98104

In association with:

BERGER/ABAM Engineers Inc.
BJT Associates
David Evans and Associates, Inc.
Entech Northwest
EnviroIssues, Inc.
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Taylor Associates, Inc.
Tom Warne and Associates, LLC
William P. Ott

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TABLE OF CONTENTS

LIST OF EXHIBITS

ATTACHMENTS

ACRONYMS

°C	degree Celsius
BA	Biological Assessment
BE	Biological Evaluation
BMP	Best Management Practice
cm	centimeter
CPS	Coastal Pelagic Species
Ecology	Washington State Department of Ecology
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ESA	Endangered Species Act
ft^2	square feet
HPA	Hydraulic Project Approval
m	meter
MLLW	mean lower low water
mm	millimeter
NMFS	National Marine Fisheries Service, now NOAA Fisheries
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NTU	nephelometric turbidity unit
PHS	Priority Habitats and Species
RM	River Mile
SMC	Seattle Municipal Code
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WSDOT	Washington State Department of Transportation
yd^3	cubic yards

Chapter 1 SUMMARY

This discipline report provides the available information used to assess and describe the potential impacts to the fish, wildlife, and vegetation potentially affected by the alternatives for replacement or repair of the Alaskan Way Seawall and the Alaskan Way Viaduct (see Appendix B, Alternatives Description and Construction Methods Technical Memorandum for details). The majority of the fish, wildlife, and vegetation resources potentially affected by any alternative are within the estuarine habitat along the City of Seattle waterfront. Thus, this discipline report focuses on this shoreline habitat. This shoreline is the transition zone between the natural habitat of Elliott Bay and the highly urbanized habitat of Seattle.

The fish, wildlife, and vegetation resources potentially affected by replacement of the Alaskan Way Seawall and the Alaskan Way Viaduct are primarily those associated with the shallow water environment of the Elliott Bay shoreline along the City of Seattle. This area extends from Pier 48 at the southern end to the seawall north of Pier 70. The biological resources of this area occur in a man-made habitat that has been produced by the original construction of the seawall at a location seaward of the natural shoreline, filling of intertidal and shallow subtidal areas, and construction of piers over much of the remaining shallow water area. Information on species and habitat within the project area was obtained from existing literature and a diver reconnaissance survey of the shallow water habitat. A variety of fishes, invertebrates, and marine algae either live within or use this habitat for a portion of their life cycle. Lists of fish, bird, mammal, and algal species potentially present and known to occur in the project area are provided (see Chapter 4, Affected Environment).

Endangered Species Act (ESA) listed fish species addressed in this report include Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*) and bull trout (*Salvelinus confluentus*). The Seattle waterfront is a migration corridor and rearing area for these and other juvenile anadromous salmonids. Both Chinook salmon and bull trout are present at times in this area.

Chinook salmon spawn in the Duwamish River upstream from River Mile (RM) 11 (WDF et al. 1993), which is many miles from the project area. Duwamish River Chinook salmon are part of the Green River fall Chinook salmon stock. This stock is currently listed as healthy based on escapement levels (WDF et al. 1993). Young Chinook from other river systems have been collected along Elliott Bay shorelines (Noble 2002 personal communication).

Little information exists regarding the current distribution of bull trout in the Duwamish River basin, but some bull trout do occur in the Duwamish River mainstem or its major tributaries (King County DNR 2000). Spawning populations have not been identified in the Duwamish/Green River or its tributaries. Anadromous bull trout could not pass upstream from the barrier provided by Howard Hanson Dam at RM 64.5. However, anadromous bull trout have been identified in the lower Duwamish River and Elliott Bay (Taylor 2003 personal communication). Bull trout produced in other river systems potentially forage along the Elliott Bay shoreline.

The bald eagle (*Haliaeetus leucocephalus*) is the only listed wildlife species addressed. Bald eagle nests have been identified within the greenbelt on the hillside along the west side of the Duwamish River about ½ mile from the southern terminus of the project site. The Seattle shoreline is a forage area for resident eagles, but is not known to be a wintering area for bald eagles (see Section 10.4.4).

No listed plant species have been identified in the project or action areas.

Essential Fish Habitat as defined by the Magnuson Stevens Act is identified for species likely to occur within the project area. A review of commercially managed fish populations potentially affected by the project alternatives and their habitat is provided (see Section 4.1.3, Essential Fish Habitat).

The purpose of the proposed alternatives is to restore reliable transportation along the Alaskan Way Viaduct route and the structural integrity of the seawall to maintain its long-term structural support of the Alaskan Way Viaduct, Alaskan Way, and waterfront buildings. The structural integrity of the existing seawall is weak as the result of its considerable age and damage to the wooden relieving platform that holds the seawall in place. This report deals almost exclusively with the seawall portion of the project because the fish, wildlife, and vegetation resources of the project area are nearly all supported by the habitat provided by the shoreline along the edge of Elliott Bay at the seawall.

The aquatic portion of the project area is located along the Seattle waterfront from the mouth of the Duwamish River East Waterway to Myrtle Edwards Park (Township 24N, Range 4E, Section 32). The existing Seattle waterfront was filled and had bulkheads constructed from the late 1800s through the early 1900s. Urban portions of the project extend from S. Spokane Street on the south through the Battery Street Tunnel up to Ward Street on the north.

The City of Seattle proposes to replace the seawall supporting the city's waterfront as part of the Washington State Department of Transportation (WSDOT) Alaskan Way Viaduct and Seawall Replacement Project (see Chapter 5, Operational Impacts and Benefits). The existing seawall currently provides support for fill under Alaskan Way and the Alaskan Way Viaduct, as well as portions of adjacent commercial buildings. Land use along the seawall corridor is primarily commercial and multifamily residential. The City of Seattle proposes to construct a new seawall, sidewalks, and a support roadway as part of replacement of the Alaskan Way Viaduct. Most alternatives for seawall replacement will require in-water work between Pier 48 and Colman Dock, where a portion of the shallow water habitat will be filled with several of the alternatives. In-water work will also be required along the remaining length of the seawall to remove the existing seawall and replace riprap at the base of the seawall.

The No Build Alternative will delay the potential impacts of the Build Alternatives until a later undefined date. Depending on future decisions, this could occur as a planned action or as an emergency response to failure of the existing seawall. The failed structural support of the existing seawall makes replacement or failure a high probability in the foreseeable future. The amount of change in fill and shaded area that would occur with failure or replacement of the seawall at some unidentified time in the future cannot be predicted.

All Build Alternatives will replace the existing seawall with a new seawall constructed on the landside of the existing seawall in the area from Colman Dock to Myrtle Edwards Park. Construction of a new seawall on the landward side of the existing seawall followed by removal of the existing seawall will increase the volume of Elliott Bay by 6,211 to 8,332 yd^3 with the various alternatives other than the Bypass Tunnel Alternative. The Bypass Tunnel Alternative will produce a 5,049-yd^3 reduction in Elliott Bay volume. The only clear difference among the alternatives is the amount of habitat affected and the nature of effects in the Pier 48 to Colman Dock area.

The following table (Exhibit 1-1) summarizes the amounts of habitat changes that will occur at this location with the various alternatives. Details of amounts of change by depth ranges are provided below in Exhibit 5-1. All Build Alternatives will replace the existing vertical seawall with a new vertical seawall. The surface area of middle and lower intertidal riprap (+6 to –4 ft MLLW) at the base of the seawall will increase with those alternatives adding new area and volume to Elliott Bay. The new area will have riprap and concrete seawall substrate similar to the existing shoreline. Those alternatives decreasing area and volume in Elliott Bay would eliminate nearly all intertidal riprap habitat between Pier 48 and Colman Dock, as well as some shallow subtidal habitat (-4 to -30 ft MLLW). Within this area, the existing Washington Street Public Boat Landing Pergola covers (shades) an area of 2,260 ft^2.

Exhibit 1-1. Amounts of Shoreline Habitat Changes for Each Seawall Replacement Alternative

Alternative	Elliott Bay		Pier 48 to Colman Dock	
	Surface Area (ft^2)	Volume (yd^3)	New Shaded Area (ft^2)	New Fill (ft^2)
No Build	unknown	unknown	unknown	unknown
Rebuild	+22,550	+7,979	32,940	0
Aerial – Rebuilt	+22,550	+7,979	32,940	0
Aerial – Frame Option	+27,010	+8,332	32,940	0
Tunnel	+10,740	+6,211	29,240	3,700
Bypass Tunnel	-1,540	-5,094	18,040	14,900
Surface	+22,550	+7,978	32,940	0

There is a Frame option to the Aerial Alternative that would also include rebuilding the seawall from Pier 48 to Myrtle Edwards Park, which would produce modified habitat, including new aquatic habitat in existing fill areas (existing seawall location). Aquatic habitat volume in Elliott Bay would increase by an estimated 8,332 yd^3, slightly more than with the Seawall Rebuild Alternative. The new aquatic habitat would result from removal of portions of the existing seawall following construction of a new seawall landward of the existing location. More material would be removed at the existing Pile-Supported Gravity Seawall area with the Frame option than with the Rebuild, Aerial Rebuild, and Surface Alternatives.

In the short area of shoreline between Pier 48 and Colman Dock, several alternatives will place new fill on the waterside of the existing seawall. The Rebuild and Aerial Alternatives will retain the seawall at its existing location between Pier 48 and Colman Dock. The Tunnel Alternative will fill 3,700 ft^2 of Elliott Bay at this location. The Bypass Tunnel Alternative will fill an area of 14,900 ft^2 at this location.

The combined seawall replacement, viaduct replacement, and expansion of the Colman Dock Ferry Terminal will result in cover over 35,200 ft^2 surface area of Elliott Bay between Pier 48 and Colman Dock. This amount includes the areas of potential fill described above for several seawall alternatives.

Construction of a new seawall and removal of the existing seawall will alter existing shoreline habitat along Seattle's Elliott Bay waterfront. Alteration of this previously developed shoreline has the potential to beneficially or adversely affect fish and wildlife that use the shoreline habitat of Elliott Bay. Additional intertidal habitat supporting juvenile Chinook salmon, bull trout, and other salmonids will be produced by all Build Alternatives from Colman

Dock north to Myrtle Edwards Park by removal of the existing seawall following construction of a new seawall.

Potential adverse effects of the proposed project on these species would be through human disturbance during construction, and temporary and localized sedimentation. Best Management Practices (BMPs) will be employed to minimize these impacts (see Chapter 9, Construction Mitigation). Potential direct effects may include temporary changes to invertebrate and algal resources in the area of sediment disruption. Cumulative effects will include continuation of the impacts produced by the existing seawall. Additional cumulative effects will be restricted to the area between Pier 48 and Colman Dock, where new fill might occur and over-water cover will be produced by the combination of seawall-viaduct replacement and the Colman Dock Ferry Terminal expansion.

Effects on juvenile Chinook salmon migrating and rearing along the Seattle shoreline will be avoided by restricting in-water work during their migration period. Construction of the new seawall will occur on the land side of the existing seawall from Colman Dock north, thus it will not be in-water work. In-water work may occur between Pier 48 and Colman Dock. The work area on the waterside of the existing seawall at the Pier 48-Colman Dock site to be modified by the tunnel alternatives will be isolated from Elliott Bay by sheet pile walls or other means during the migration period, or work will be conducted outside the juvenile migration period. Juvenile salmon and bull trout are potentially present from March 15 through July 15. Effects on potential wintering bald eagles will be limited to increased activity along the seawall where activity is currently intense. This shoreline area will be permanently altered by the tunnel alternatives that will extend the vertical wall into Elliott Bay.

Although eagles forage along the Seattle waterfront, only a small portion of this area will be disrupted at any specific time. Bald eagle use of the area is not intense, as there are no pools, side channels, or other features that would likely attract large numbers of eagle prey to the project site. The existing seawall is the site of heavy vehicle traffic and intense human activity. Any potential disturbance to foraging behavior is likely to be temporary and minimized by the more suitable foraging habitat that exists in more natural Elliott Bay shoreline areas and upstream in the Green-Duwamish River.

No natural intertidal habitat remains within the project area. The subtidal soft substrate habitat appears to be generally natural, with large amounts of debris. However, most of this habitat has been previously dredged or has piers constructed over the remaining natural elevations.

The benthic invertebrates and macroalgae living on the hard substrates and the soft substrate at the base of the seawall will be removed or displaced during removal of the existing seawall and placement of new riprap. The same species are expected to recolonize the new substrate beginning at the completion of each segment. No substantive changes in substrate type are proposed, other than with those alternatives (Tunnel and Bypass Tunnel, see Table 1-1) that would fill a portion of the area between Pier 48 and Colman Dock. At this location, those alternatives would replace a portion of the soft bottom and the shoreline riprap with new concrete seawall and AWV tunnel. All alternatives will also place a new over-water roadway connecting Pier 48 to the expanded Colman Dock along the shoreline. A shallow water area of 35.200 ft^2 would be covered that currently supports macro algae over the subtidal area and has either riprap or seawall in the intertidal area. A portion of this 35.200 ft^2 will be filled with the Tunnel and Tunnel Bypass Alternatives.

Fish commonly observed in these areas includes seaperch, bay pipefish, shiner perch, sculpins, greenling, various flatfishes, and a few lingcod. Common macroinvertebrates include red crab, hairy crab, coonstripe shrimp, various sea stars, and anemones. A wide variety of smaller invertebrates lives on and within the substrates.

Opportunities to restore habitat functions have been identified for various locations along the Seattle shoreline (see Habitat Restoration Opportunities Memorandum, Attachment D). Decisions to be made later will determine the appropriate actions to restore lost habitat functions as a part of the proposed project. Discussions are currently being undertaken with permitting and resource agencies to determine appropriate habitat restoration actions to be included in the project.

Chapter 2 METHODOLOGY

2.1 Data Collection

Data were collected from available published sources as well as directly from resource agencies. Agencies were contacted to obtain materials providing information on existing fish, wildlife, and vegetation resource conditions along the Alaskan Way Viaduct Corridor. Information obtained was used to characterize and assess potential impacts from the project alternatives. Project engineers provided information on the physical aspects of the alternatives for the Alaskan Way Seawall and the Alaskan Way Viaduct that would potentially alter the existing habitat characteristics and the biota inhabiting the project area.

2.2 Existing Conditions Information

Existing conditions that could be changed by one or more of the project alternatives (see Appendix B, Alternatives Description and Construction Methods Technical Memorandum) are identified along the project corridor. Information on habitat physical and biological characteristics was collected to provide a description of existing baseline conditions for use in the analysis and discussion of potential impacts through both existing data sources and several reconnaissance surveys by Parametrix biologists (March 4, May 14, and June 4–5, 2002).

Physical habitat characteristics were described from a combination of existing information and a visual survey of the shoreline characteristics along the Seattle waterfront. This information provided the basis of a description of the environmental baseline, the project setting, and information on the past and present activities along the project alignment. Information was gathered on all species of fish, wildlife, and vegetation previously identified and likely to occur within the project area.

2.2.1 Endangered, Threatened, and Proposed Species and Habitat Occurrence

Species listed under the ESA by National Marine Fisheries Service (NOAA Fisheries) and U.S. Fish and Wildlife Service (USFWS) were obtained from the Services (NOAA Fisheries web site: http://www.nwr.noaa.gov/1salmon/salmesa/index.htm; USFWS web site: http://endangered.fws.gov/wildlife.html#Species). Species potentially listed during the development of the project were identified based on knowledge of the project biologists and information provided by WSDOT and/or the City of Seattle. Types of information obtained and included in these data sources include the following.

Anadromous Fish Run Data: Past and recent fish run data were obtained to provide information on the current status of the anadromous stocks migrating through Elliott Bay and using the habitat potentially affected by Alaskan Way Viaduct alternatives. The local status of listed species was identified through this effort.

Juvenile Salmonid Data for Migration and Rearing in Lower Duwamish River and Elliott Bay: Numerous investigations have been conducted by the Port of Seattle, the Tribes, and others to identify characteristics of the juvenile salmon and the habitat they use as they migrate through the project area. Information on the timing, habitat characteristics, prey resources utilized, potential predators, etc., was obtained from published and unpublished literature sources.

Existing Habitat Conditions: Information on the existing physical conditions of the shoreline habitat along the Seattle waterfront was obtained from the City of Seattle and the Port of Seattle. A visual survey of the existing habitat was conducted from a boat, by divers, and from the shoreline to provide specific information on habitat conditions to adequately describe habitat conditions along the area potentially affected by the project alternatives.

Recommend Conservation Measures: Development of habitat conservation measures may be necessary to meet permit and ESA requirements. Conceptual measures to restore important habitat functions for support of the listed species within the Action Area have been identified and developed in cooperation with resource agency representatives to improve habitat for the listed species (Attachment D). Conceptual monitoring plans for conservation measures were developed.

2.2.2 Essential Fish Habitat

The Magnuson-Stevens Act requires proposed projects with a federal nexus to evaluate potential impacts to habitat of commercially managed fish populations. Lists of salmon, groundfish, and pelagic species potentially affected by the proposed project alternatives and identified under the Magnuson-Stevens Act are compiled and evaluated to determine those likely to use shoreline habitat potentially altered by the proposed project alternatives. Alterations of habitat supporting members of these groups are identified and potential impacts described.

2.3 Mitigation/Habitat Enhancement

The shoreline habitat provided by the existing seawall is highly modified from its natural historic condition. Vertical bulkheads in the intertidal zone are the least suitable habitat type for ESA listed species as well as all other species of interest. Because this is a migratory corridor for juvenile Chinook

(ESA listed) and other juvenile salmon and the existing conditions are highly modified shoreline with vertical bulkhead for more than a mile of shoreline, this shoreline is important to the major run of Chinook and chum salmon produced in the Green-Duwamish River. Juvenile salmon produced in other watersheds also use the Elliott Bay shoreline habitat. Actions to restore juvenile salmon rearing and migrating functions will likely be required as mitigation and habitat enhancement along the shoreline as a condition of permit approval for any revisions to the existing seawall.

Permit conditions will likely seek restoration of more natural habitat characteristics wherever possible along the Seattle shoreline. These characteristics include:

- Gradual intertidal slopes, to the degree possible.
- Fine grain substrate (mixtures of sand-gravel-cobble).
- Absence of shading on the restored habitat.

Mitigation requirements will differ among the alternatives and will not be known until a preferred alternative is selected and discussions with resource agencies progress. Habitat restoration actions in addition to mitigation requirements may be incorporated into the selected alternative.

Initial identification of potential mitigation and habitat restoration options has been conducted through coordination with resource agencies. A memorandum identifying potential enhancement opportunities along the Seattle waterfront was submitted to various resource agencies (see Attachment D). Specific mitigation and habitat restoration options will be identified through additional coordination with resource agencies and development of the design of a preferred alternative for the seawall and Alaskan Way Viaduct. These options will attempt to restore the physical characteristics identified above as a means to partially restore habitat functions to the shoreline habitat.

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Chapter 3 STUDIES AND COORDINATION

Coordination was conducted with and information was obtained from the following agency and tribal sources:

- NOAA Fisheries
- USFWS
- Muckleshoot Tribe
- Suquamish Tribe
- Snoqualmie Tribe
- Duwamish Tribe
- Washington Department of Fish and Wildlife
- Washington Department of Natural Resources
- Washington Department of Ecology
- City of Seattle
- Port of Seattle
- The Seattle Aquarium
- King County
- University of Washington, Fisheries Research Institute

Information gathered from agencies and existing information sources included:

- Species listed under ESA.
- Fish and invertebrate species present, use of habitat present.
- Species habitat requirements, life stages, and timing in project area.
- Habitat descriptions.
- Information on impacts to species from potential construction and operation features.

Site-specific information was also gathered through a diver reconnaissance survey, including shoreline substrate characteristics, aquatic vegetation species and distribution, benthic macrofauna species and general abundance, and shoreline bathymetry (Parametrix dive team: Don Weitkamp, David Gillingham, Bill Peters, June 4 and 5, 2002). A video record was made of visible biota and substrate conditions at representative locations along the Alaskan Way Seawall.

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Chapter 4 AFFECTED ENVIRONMENT

The Alaskan Way Seawall is a 70-year-old structure that extends along Seattle's Elliott Bay waterfront from the northern edge of Pier 48 north to Myrtle Edwards Park (Exhibit 4-1). The seawall was constructed with a concrete face supported by untreated wood that has deteriorated over time and is no longer structurally sound. The existing seawall will be reconstructed as part of the project to replace the existing Alaskan Way Viaduct. See Appendix B, Alternatives Description and Construction Methods Technical Memorandum for detailed descriptions of alternative actions.

4.1 Project Area

The Alaskan Way Viaduct and Seawall Replacement Project area extends from S. Spokane Street on the south through the Battery Street Tunnel up to Ward Street on the north. However, the portion of the project area where the majority of the proposed Alaskan Way Viaduct and Alaskan Way Seawall restoration will affect fish, wildlife, and vegetation resources is the Seattle waterfront from Pier 48 north to Myrtle Edwards Park.

For this analysis, the project area is defined as the immediate work and construction area together with all Elliott Bay waters and habitat within ¼ mile of the Seattle shoreline. This area is appropriate to identify all fish and terrestrial species potentially affected by construction and operation activities. Fish habitat includes the intertidal shoreline and shallow subtidal area (<-60 ft MLLW) of Elliott Bay along the Seattle waterfront. Wildlife habitat includes the surface water of Elliott Bay along the Seattle shoreline and the urban environment of the Seattle nearshore. Vegetation habitat includes the shallow subtidal bottom of the nearshore along with a few street trees planted along Alaskan Way and other streets potentially modified by the proposed alternatives.

The project has the potential to affect anadromous fish resources within Water Resource Inventory Area 9 (Green-Duwamish River). The Duwamish River is that portion of the Green/Duwamish River system from the former confluence of the Black River (RM 11.0) to Elliott Bay (RM 0.0). The name Duwamish River applies to the first 11 miles of the river, while the term Green River applies to both the river above RM 11.0 and the entire river system. Historically, the Green, White, Black, and Cedar Rivers flowed into the Duwamish River, and the system drained an area of over 1,600 square miles. In the early 1900s, the White River was diverted from the Green River, and the Black and Cedar Rivers were diverted to Lake Washington, reducing the Green River drainage to just 483 square miles (Blomberg 1995). The White

River was part of the Green River System, but was permanently diverted to the Puyallup River drainage in 1906 (Weitkamp and Ruggerone 2000). In 1913 the City of Tacoma constructed a diversion dam on the Green River at RM 50. In 1963, the Howard Hanson Dam was built at RM 53.0. Both of these structures completely block fish migration to the upper Green River and its tributaries. The saltwater wedge extends 8.7 miles upstream in the Duwamish River at high tide (Grette and Salo 1986).

Shoreline habitat along the Seattle waterfront and the Duwamish estuary has been highly modified by urban development (Exhibit 4-1). Although no action will be taken within the Duwamish estuary with any alternatives, the project will potentially affect the biological resources using the Duwamish estuary. No natural shoreline remains along the waterfront from the Duwamish River mouth to the northwestern corner of Elliott Bay. Exhibit 4-2 shows cross sections of the various seawall types that currently exist along the Seattle shoreline. The basic habitat is vertical concrete within the intertidal zone, with rock riprap at lower intertidal or shallow subtidal elevations along much of the seawall. Nearly half the shoreline length has piers extending from the shoreline over shallow subtidal area. Exhibit 4-3 provides a summary of physical characteristics of this shoreline habitat. Less than 2 percent of the Duwamish estuary's pre-development mudflat, sandflat, and intertidal wetlands remains (King County 2000). The remaining natural habitat consists of small marginal areas along the Duwamish Waterway.

The largest single remaining area of intertidal habitat is located around Kellogg Island, which is located within the Duwamish River estuary at RM 1.25 (King County 2000). No natural shoreline habitat currently exists between the Duwamish River and Pier 89 at the north end of Elliott Bay. The estuary shoreline has lost 21,000 ft due to channel straightening and 53,000 ft due to filling and development. Only 19,000 ft of vegetated riparian shoreline remains, all of which is upstream from the mouth of the Duwamish River. Likewise, the eastern shoreline of Elliott Bay in the project area has been highly modified by bulkheads (seawall) and filling of the natural intertidal habitat from the mouth of the Duwamish estuary to the north end of the bay.

General Elliott Bay conditions and the Duwamish River jointly influence the water quality characteristics of the habitat. Duwamish River conditions near the project site have potential limiting condition with high temperatures and low dissolved oxygen levels having occurred in the past downstream from RM 5.2 during summer low-flow periods. The Duwamish River is on the Washington State Department of Ecology's 303(d) list of impaired water bodies for multiple sites and parameters, with most listings for sediment quality rater than water quality (Ecology 2000).

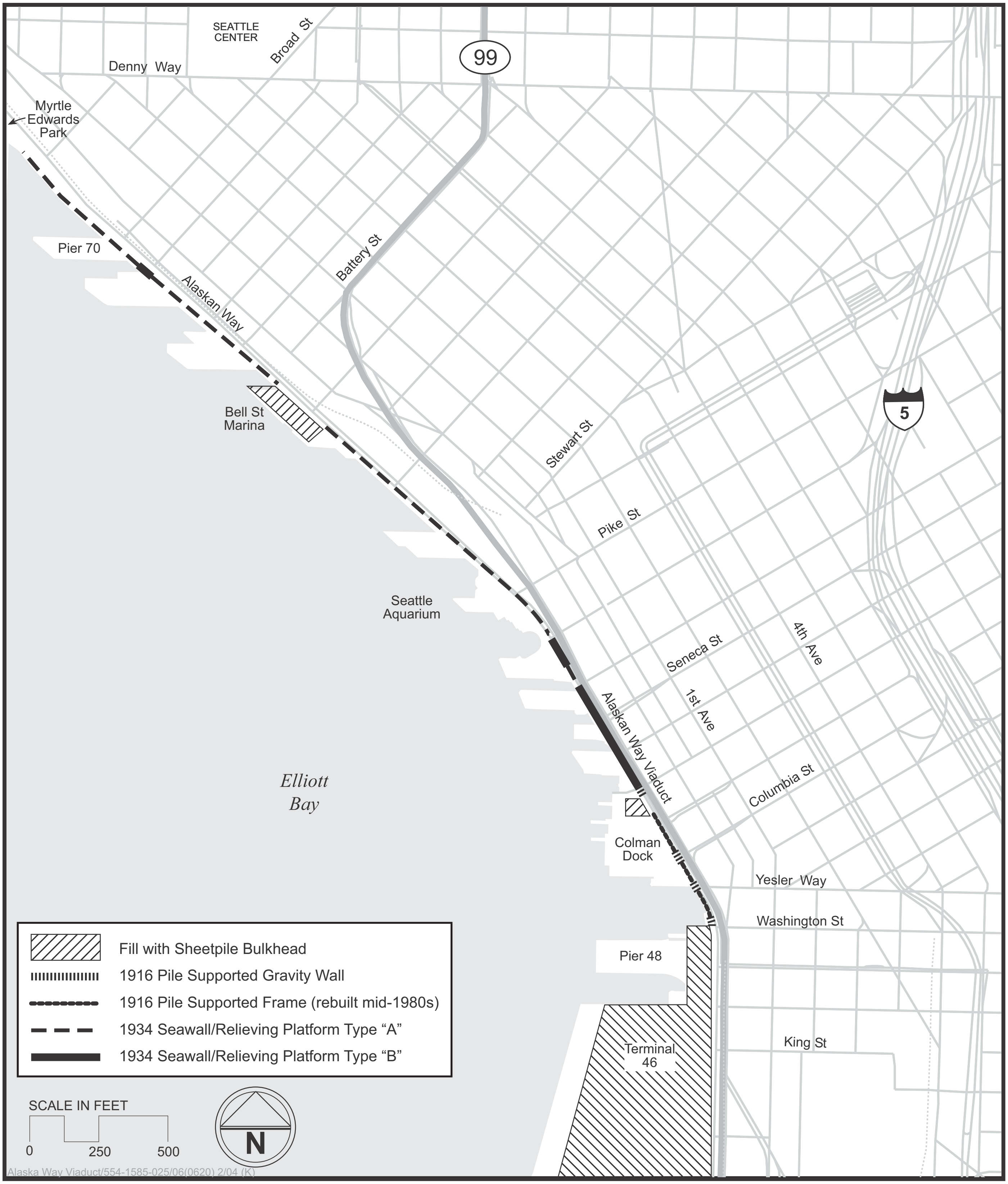
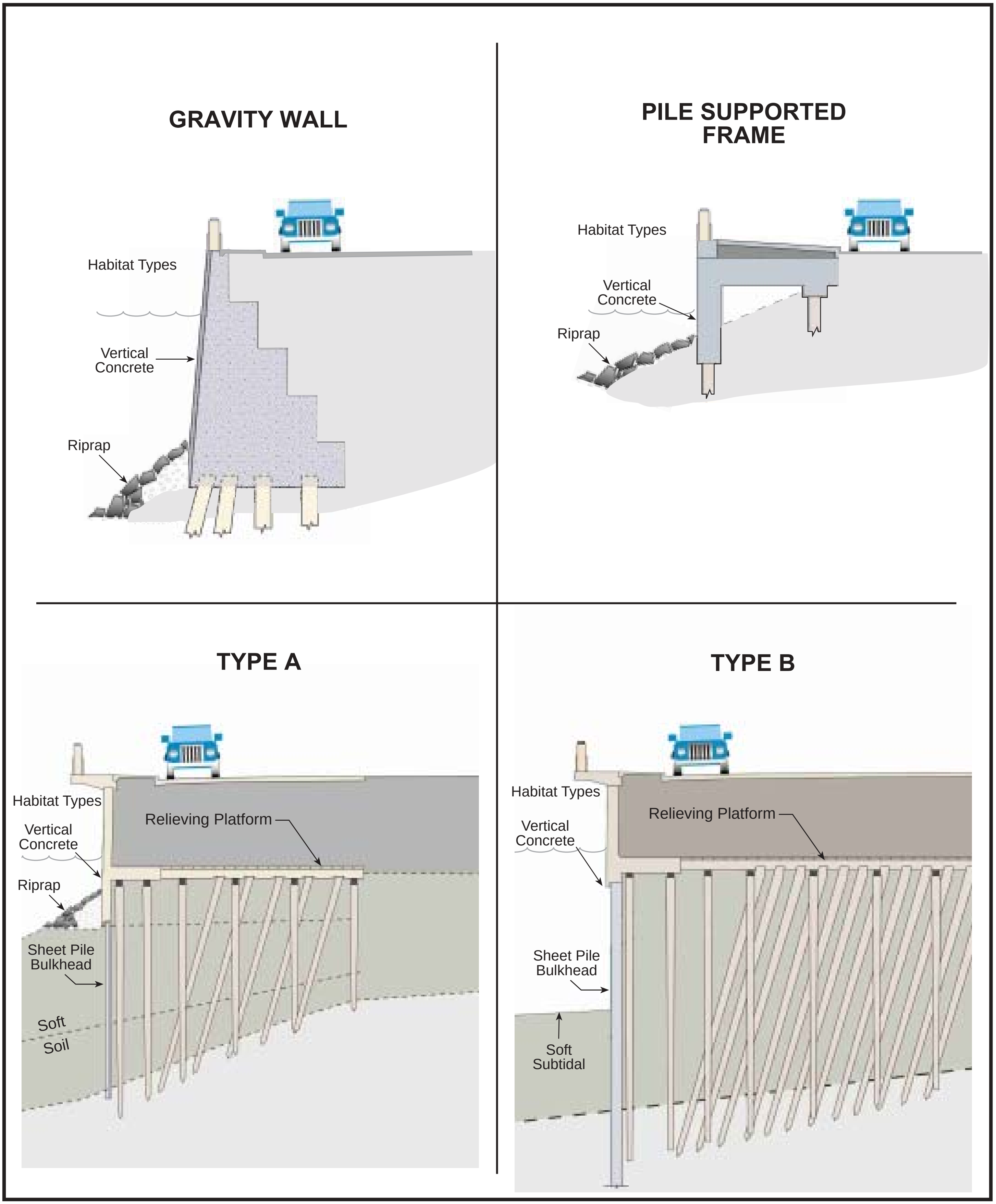


Exhibit 4-1
Alaskan Way Seawall Structure Locations



Source: Berger/Abam Engineers, Inc.

Exhibit 4-2
Cross-Sections of Various Alaskan Way Seawall Types Showing Habitat Basic Physical Characteristics

Exhibit 4-3. Seattle Shoreline General Intertidal Physical Characteristics Based on Visual Survey and Previous Port of Seattle Survey

Segment (Length ft)	Existing Characteristics Between Piers	Port Characterization
Pier 46–48 (230)	Intertidal riprap fill with some sand-gravel at a moderate slope, (southern ½ to 6-8 ft MLLW, northern ½ to 3-4 ft MLLW), curved apron over northern edge. Southern 100 ft filled ~120 ft from shore. Well protected area.	230 ft vertical concrete bulkhead, riprap toe at 2-3 ft MLLW.
Pier 48 (380)	Shoreline fill and appears to have fill on original bottom to relatively shallow subtidal depths under pier. Wood pile -supported pier.	Not identified.
Pier 48–52, Old Alaska Marine Highways pier to Colman Dock Ferry Terminal (280)	Vertical concrete bulkhead middle to upper intertidal, ~420 ft wide between piers. Fill ~130 ft wide by 170 ft adjacent to Pier 48 steel sheet pile in poor condition. Large riprap as high as ~6 ft MLLW in center of shoreline.	450 ft vertical concrete bulkhead with riprap toe at 2-3 ft MLLW.
Pier 52, Washington State Ferry Terminal (Colman Dock) (840)	1,260 ft wide pier with mix of concrete and timber piles, sheet pile along northern portion of shoreline.	1,260 ft exposed vertical concrete bulkhead, riprap toe at 2-3 ft MLLW.
Fire Station, Piers 54–57 Ivar's (350)	Wood pile-supported piers line most of shoreline.	2,030 ft wood piers with vertical bulkhead & and riprap toe at 2-3 ft MLLW; 620-ft vertical concrete bulkhead.
Pier 58 to Waterfront Park (1,100)	Wood pile-supported pier.	Part of above 2,030 ft.
Seattle Aquarium (400)	Wood pile-supported pier.	Part of above 2,030 ft.
Aquarium to Pier 62/63 (170)	Vertical concrete bulkhead, wood pile -supported pier.	Part of above 2,030 ft.
Pier 62/63 (250)	Wood deck over shoreline ~300 ft wide	Part of above 2,030 ft.
Piers 62/63–66 Marina (1,650)	Vertical concrete bulkhead with riprap toe to 4-6 ft MLLW.	900 ft concrete piling pier with riprap slope, 1,300 ft vertical concrete bulkhead with riprap toe at 2-3 ft MLLW, 930 ft wood pier with vertical concrete bulkhead and riprap toe at 2-3 ft MLLW.
Piers 66–70 (1,700)	Wood and concrete pile supported piers with short expanses of vertical bulkhead between piers.	Part of above 900 ft.
Myrtle Edwards Park (880)	Vertical concrete bulkhead with riprap toe to 2-3 ft MLLW, about 850 ft long. Highly exposed to wind waves except for southern end, which is protected by Pier 70.	Exposed 900 ft vertical concrete bulkhead with riprap toe at 2-3 ft MLLW.

Source: George Bloomberg, Port of Seattle (2002).

4.1.1 Existing Seawall

The existing Alaskan Way Seawall extends from S. Washington Street (Exhibit B-1, Attachment B) up to Myrtle Edwards Park (just north of Broad Street) (Exhibit B-5). In addition, there is a small section located between S. King Street and S. Washington Street where the upland is supported by a steel sheet pile wall. This sheet pile is sufficiently corroded that material has been lost from the upland area. The sheet pile will be replaced as part of most alternatives for the Alaskan Way Viaduct and Seawall Replacement Project.

The seawall consists of multiple sections with three different structure types. The locations of these structure types are shown in Exhibit 4-1. Cross sections of the structure types are described below and shown in Exhibit 4-2. They include:

- Pile-Supported Gravity Wall and Pile-Supported Frame from S. Washington Street to Madison Street (Exhibit B-1).
- Type B Seawall – From about Madison Street to Union Street and a small section at Clay Street (Exhibits B-3 and B-4).
- Type A Seawall – Located from Union Street up to Myrtle Edwards Park (Exhibit B-2).

The Pile-Supported Gravity Wall is made of an unreinforced concrete slab supported by timber piles. The concrete slab is about 12 ft thick at the base and narrows at higher elevations. Riprap has been placed on the waterside of the concrete slab. The Pile-Supported Frame supports sections of sidewalk and is built of unreinforced concrete supported by timber piles.

Type B Seawall is built with steel sheet pile wall on the bottom of the water side with a concrete face attached to the top. The steel sheet pile wall is exposed to the marine waters of Elliot Bay (Exhibit B-3). A timber relieving platform and wood piles support the sheet pile wall and concrete face. The timber-relieving platform extends from 40 to 80 ft east of the sheet pile wall and is about 15 ft under Alaskan Way.

Type A Seawall is similar to the Type B Seawall with only concrete exposed to the marine waters of Elliott Bay. The relieving platform for the Type A wall extends up to 40 ft east of the seawall.

4.1.2 Fish

The nearshore waters of Elliott Bay and the Seattle shoreline provide habitat potentially supporting a wide variety of fish that could potentially be affected by alternatives being considered for replacement/repair of the Alaskan Way Seawall and Alaskan Way Viaduct. These fish resources include marine species living from prolonged periods or their entire life in Elliott Bay to anadromous salmonids that pass along the shorelines as juveniles and possibly as adults.

Exhibit 4-4 provides an inclusive list of fish species (in phylogenetic order) likely to be found in the project area. Although most of these fishes would not likely be present at the seawall, individuals of many species are at least occasionally present at or near the seawall. Fish species commonly observed in the shoreline area along the seawall include seaperch, bay pipefish, shiner perch, sculpins, greenling, various flatfishes, and a few lingcod. Juvenile salmon are commonly present at various protected locations near the surface during the spring migration.

Exhibit 4-4. Fish Species Likely to Occur Along the Seattle Waterfront

Common Name	Scientific Name	Occurrence
Pacific lamprey	*Entosphenus tridenatus*	occasional
spiny dogfish	*Squalus acanthias*	common
brown cat shark	*Apristurus brunneus*	occasional
sixgill shark	*Hexanchus griseus*	occasional
big skate	*Raja binoculata*	rare
longnose skate	*Raja rhina*	occasional
ratfish	*Hydrolagus colliei*	common
Pacific herring	*Clupea harengus pallasi*	rare
northern anchovy	*Engraulis mordax*	rare
chum salmon	*Oncorhynchus keta*	common
Chinook salmon	*Oncorhynchus tshawytscha*	common
coho salmon	*Oncorhynchus kisutch*	common
rainbow trout/steelhead	*Oncorhynchus mykiss*	common
cutthroat trout	*Oncorhynchus clarki*	occasional
bull trout/Dolly Varden	*Salvelinus confluentus/Salvelinus malma*	rare
surf smelt	*Hypomesus pretiousus*	common
longfin smelt	*Spirinchus thaleichthys*	occasional
Lingcod	*Ophiodon elongatus*	occasional
Cabezon	*Scorpaenichthys marmoratus*	occasional

Exhibit 4-4. Fish Species Likely to Occur Along the Seattle Waterfront (continued)

Common Name	Scientific Name	Occurrence
kelp greenling	*Hexagrammos decagrammus*	common
Pacific cod	*Gadus macrocephalus*	occasional
Pacific hake	*Merluccius productus*	common
Pacific tomcod	*Microadus proximus*	common
walleye pollock	*Theragra chalcogramma*	common
blackbelly eelpout	*Lycodopsis pacifica*	common
Tube-snout	*Aulorhynchus flavidus*	common
threespine stickleback	*Gasterosteus aculeatus*	occasional
bay pipefish	*Syngnathus leptorhynchus*	common
shiner perch	*Cymatogaster aggregata*	common
striped perch	*Embiotoca lateralis*	common
pile perch	*Rhacochilus vacca*	common
snake prickleback	*Lumpenus sagitta*	common
Pacific sand lance	*Ammodytes hexapterus*	common
brown rockfish	*Sebastes auriculatus*	occasional
quillback rockfish	*Sebastes maliger*	common
China rockfish	*Sebastes nebulosus*	occasional
copper rockfish	*Sebastes caurinus*	common
yellowtail rockfish	*Sebastes flavidus*	common
black rockfish	*Sebastes mulonops*	common
Bocaccio	*Sebastes paucispinis*	occasional
canary rockfish	*Sebastes pinniger*	occasional
prickley sculpin	*Cottus asper*	occasional
buffalo sculpin	*Enophrys bison*	occasional
Pacific staghorn sculpin	*Leptocottus armatus*	common
Dover sole	*Microstomus pacificus*	common
English sole	*Parophrys vetulus*	common

Exhibit 4-4. Fish Species Likely to Occur Along the Seattle Waterfront (continued)

Common Name	Scientific Name	Occurrence
flathead sole	*Hippoglossoides elassodon*	occasional
Pacific sanddab	*Citharichthys sordidus*	occasional
petrale sole	*Eopsetta jordani*	occasional
rex sole	*Glyptocephalus zachirus*	occasional
rock sole	*Lepidopsetta bilineata*	occasional
C-O sole	*Pleuronichthys coenosus*	common
sand sole	*Psettichthys melanostictus*	occasional
starry flounder	*Platichthys stellatus*	occasional

Sources: Matsuda et al. (1968); DeLacey et al. (1972); Weitkamp and Ruggerone (2000).

The Duwamish estuary and the Seattle Waterfront provide both a migration corridor and rearing area for anadromous salmon and possibly bull trout (Weitkamp and Ruggerone 2000). Juvenile salmon migrate from their Green River spawning-rearing areas through the Duwamish estuary across the Seattle waterfront during their migration to the ocean. Juvenile salmon and bull trout from other river systems also migrate along the Elliott Bay shorelines. Returning adult salmon migrate through Elliott Bay with some potentially moving in the general vicinity of the Seattle waterfront. Three species of anadromous Pacific salmon inhabit the Green/Duwamish River basin: Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), and chum (*O. keta*) salmon. Pink (*O. gorbuscha*) and sockeye (*O. nerka*) salmon may occasionally be seen in the Green River basin, but the Green River is primarily a chum, coho, and Chinook salmon stream (Williams et al. 1975). Sockeye salmon generally require a rearing lake below or near their spawning area, although sockeye salmon are occasionally seen in streams that are not tributary to lakes (Foerster 1972). Other anadromous salmonids using these waters include steelhead (*O. mykiss*), sea-run cutthroat trout (*O. clarki*), Dolly Varden (*Salvelinus malma*), and bull trout (*Salvelinus confluentus).*

Site-Specific Salmon Information

Information describing the fish resources of the Elliott Bay shoreline along the Alaskan Way Seawall has been generated by a variety of investigations. Most efforts to investigate juvenile salmon in the project vicinity have focused on the Duwamish River estuary and/or the Pier 90/91 areas. During construction of Terminal 46 at the southern end of the Alaskan Way Seawall, Weitkamp (1977) found Chinook (75 to 100 mm) and chum (55 to 95 mm) fry as well as a few Chinook smolts (120 to 160 mm) along the shorelines and along the edges of piers over deep water (-10m, -33 ft mean lower low water, MLLW). This shoreline was extremely turbid during June when the salmon were collected. Turbidity was attributed to wind and wave action along the shoreline.

In 1983 Parametrix (1984) sampled juvenile salmon within the estuarine areas of the Port of Seattle from the upstream end of the estuary to the downstream portions of Elliott Bay from late March through mid-May. Nine purse seine sites were sampled along pier aprons and five sites were sampled by beach seine. Chum fry were present in shallow water by late March, shortly after sampling began. Several peaks in their abundance were seen, one in early May, and one in mid-May. Few chum were caught over deeper water by purse seine until late May, when the numbers in beach seine catches were declining. Only a few Chinook were caught through mid-May. Chinook were found in moderate numbers at Duwamish River stations in late May and June, while only in mid-June were many Chinook caught at Elliott Bay stations. Juvenile coho were also taken in moderate numbers in late May and June in the Duwamish estuary, but seldom at any Elliott Bay location.

Chum fry were in the range of 40 to 45 mm (mean length) through mid-April in the beach seine catches. Apparently the larger fish left the area and were replaced by smaller fish. Chum fry caught by purse seine over deeper water were larger than those taken by beach seine. The chum were about 52 mm in mid-May and steadily increased to more than 75 mm by late May. This difference provides an indication that the larger chum were continuously migrating out of the area.

Weitkamp and Schadt (1982) observed the behavior of young salmon along the Elliott Bay shoreline in the vicinity of Pier 90/91. Chum fry were abundant at Terminal 91 when the observations began in early May. A few coho and Chinook were also present. In late May the species present changed to half chum and half Chinook, then to nearly all Chinook by the end of May. The chum tended to concentrate along the edge of the pier aprons toward the shore end of the piers. Much smaller numbers of chum were seen along the gently sloping shorelines with natural substrates. The chum along the piers were feeding close to the surface with apparently random darting movements along the first row of piles supporting the aprons and boom logs tied to the pier edge. None of the juvenile salmon appeared much past the first row of piles under the pier aprons or more than 2 to 4 m (6 to 13 ft) from the piers. The fish readily passed under a detached portion (9 to 12 m, 20 to 38 ft wide) of one pier, but showed great reluctance to pass into the dark area beneath the wood pile-supported apron. All chum and Chinook were within 2 m (6 ft) of the surface, and most within 1 m (3 ft). Some of the coho were observed as deep as 3 m (10 ft).

Recently an investigation at the Bell Harbor Marina (Taylor and Willey 1997) found juvenile chum were present in small numbers when the observations began in late April. The chum peaked in early May, then remained in small numbers from early June to early July. Chinook were first observed in early May, peak numbers were seen in late June, and a few in early July.

At the marina, Chinook and coho were observed passing through a shoreline opening in the breakwater structure provided for fish passage. Juvenile chum were present in schools of 25 to 500 fish at sizes of 50 to 80 mm. Chum were always within 0.6 to 4.5 m (2 to 15 ft) of structures, and close to the surface down to as deep as 3 m (10 ft). Chinook and coho were commonly observed as individuals and in schools of 10 to 50 fish. Chinook were in the size range of 150 to 250 mm. Chinook appeared first in May, peaked in late June, and disappeared in July. They appeared to have a slow migration rate and were commonly seen at depths of 1.6 to 6 m (5 to 20 ft).

Potential avian predators present (western grebe, belted kingfisher, gulls, mergansers) were not more numerous near the marina than in the general vicinity. No avian predation was observed. Avian predators were not observed near the shoreline passage facility, although avian predators were frequently seen along the shoreline.

4.1.3 Essential Fish Habitat

The Magnuson-Stevens Act requires proposed projects with a federal nexus (funding) to evaluate potential impacts to habitat of commercially managed fish populations. This Act regulates salmon, groundfish, and pelagic fish. Essential fish habitat (EFH) has been defined for the purposes of the Magnuson-Stevens Act as "*those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity*" (NMFS 1999b). NOAA Fisheries has further added the following interpretations to clarify this definition:

- "Waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate.
- "Substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities.
- "Necessary" means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem.
- "Spawning, breeding, feeding, or growth to maturity" covers the full life cycle of a species.

Salmon

NOAA Fisheries has recently proposed EFH for Pacific Coast salmon, including Chinook, within Amendment 14 to the Pacific Coast Salmon Plan (NMFS 2000b). Any reasonable attempt to encourage the conservation of EFH must take into account for actions that occur outside of EFH, such as upstream and upslope activities that may have an adverse effect on EFH.

Chapter 3, Section 3.2.5.5 of Amendment 14 (NMFS 2000b) addresses construction/urbanization impacts upon salmon habitat. Construction projects can significantly alter the land surface, soil, vegetation, and hydrology and can adversely affect salmon EFH through habitat loss or modification. Replacement of the Alaskan Way Seawall will involve work within Elliott Bay and its riparian zone, including excavation and soil compaction, which are activities of concern under EFH guidelines. Among numerous types of non-fishing activities that may affect EFH (should BMPs fail), those possibly applicable to the project area include actions that would:

- Alter sediment delivery and quantity in streams and estuaries.
- Alter water flow, quantity, timing, temperature, or chemistry.
- Alter the amount or types of nutrients or prey.
- Alter estuarine habitat (including water quality, eelgrass beds, tideflats, channels, and marshes).
- Discharge pollutants, nutrients, or contaminants.

Replacement of the Alaskan Way Seawall with any alternative is not expected to adversely alter sediment delivery, water flow, temperature, chemistry, or nutrients. It will produce a short-term, local alteration of prey resources at the project site during construction of the new in-water structures (Pier 48 to Colman Dock) and removal of the old structures. Following construction, the amount of habitat supporting prey resources will be increased with most alternatives (see Chapter 5, Operational Impacts and Benefits).

The use of BMPs during construction should avoid and minimize any potential effects on salmon EFH. Examples of BMPs are stated in the NMFS (2000b) EFH guidance. They include minimizing the time disturbed lands are left exposed; using erosion prevention and sediment control methods; and using methods such as sediment ponds, sediment traps, or other facilities designed to slow water runoff and trap sediment and nutrients. Specific conservation measures taken are addressed in Chapter 9, and potential effects on EFH are listed in Chapters 6 and 7.

Groundfish

The West Coast groundfish make up a diverse set of organisms. NMFS (1998c) has defined EFH for a group of 83 groundfish species as being all waters from the mean high water mark line and the upriver extent of the saltwater intrusion in river mouths along the coasts of Washington, Oregon, and California. Accordingly, the Alaskan Way Seawall and the Pier 48 to Colman Dock areas have EFH for those West Coast groundfish that may be present in the area. Exhibit 4-5 lists the groundfish species that may have EFH in the project area, although not all have been identified from the project area (Exhibit 4-4). Individual species were identified by comparing NOAA Fisheries' review of West Coast groundfish (Casillas et al. 1998) with the distribution of these fish as presented in Hart (1973) and DeLacey et al. (1972). Taken as a whole, these fish species use a wide variety of habitats, including estuarine, rocky shelf, non-rocky shelf, canyon, neritic, and oceanic habitats.

Elliott Bay provides benthic habitat of the general type used by some of the groundfish species. These species are most likely to be found in the moderate to deep subtidal areas of Elliott Bay. However, small numbers of a few species may be found associated with the piers and open shallow areas along the Elliott Bay shoreline. These species include spiny dogfish, ratfish, kelp greenling, copper rockfish, English sole, and starry flounder.

Exhibit 4-5. West Coast Groundfish Present in Washington Coastal Waters and Potentially in the Project Vicinity

soupfin shark (*Galeorhinus zyopterus*)	rosy rockfish (*Sebastes rosaceus*)
spiny dogfish (*Squalus acanthias*)	rougheye rockfish (*Sebastes aleutianus*)
big skate (*Raja binoculata*)	sharpchin rockfish (*Sebastes zacentrus*)
longnose skate (*Raja rhina*)	shortbelly rockfish (*Sebastes jordani*)
ratfish (*Hydrolagus colliei*)	shortraker rockfish (*Sebastes borealis*)
roughscale rattail (*Coryphaenoides acrolepis*)	silvergray rockfish (*Sebastes brevispinis*)
lingcod (*Ophiodon elongatus*)	splitnose rockfish (*Sebastes diploproa*)
cabezon (*Scorpaenichthys marmoratus*)	stripetail rockfish (*Sebastes saxicola*)
kelp greenling (*Hexagrammos decagrammus*)	tiger rockfish (*Sebastes nigrocinctus*)
Pacific cod (*Gadus macrocephalus*)	vermilion rockfish (*Sebastes miniatus*)
Pacific whiting (hake) (*Merluccius productus*)	widow rockfish (*Sebastes entomelas*)
aurora rockfish (*Sebastes aurora*)	yelloweye rockfish (*Sebastes ruberrimus*)
black rockfish (*Sebastes melanops*)	yellowmouth rockfish (*Sebastes reedi*)
blackgill rockfish (*Sebastes melanostomus*)	yellowtail rockfish (*Sebastes flavidus*)
blue rockfish (*Sebastes mystinus*)	shortspine thornyhead (*Sebastolobus alascanus*)

Exhibit 4-5. West Coast Groundfish Present in Washington Coastal Waters and Potentially in the Project Vicinity (continued)

bocaccio (*Sebastes paucispinis*)	longspine thornyhead (*Sebastolobus altivelis*)
brown rockfish (*Sebastes auriculatus*)	arrowtooth flounder (*Atheresthes stomias*)
canary rockfish (*Sebastes pinniger*)	butter sole (*Isopsetta isolepis*)
chilipepper (*Sebastes goodei*)	curlfin sole (*Pleuronichthys decurrens*)
China rockfish (*Sebastes nebulosus*)	Dover sole (*Microstomus pacificus*)
copper rockfish (*Sebastes caurinus*)	English sole (*Parophrys vetulus*)
darkblotched rockfish (*Sebastes crameri*)	flathead sole (*Hippoglossoides elassodon*)
greenspotted rockfish (*Sebastes chlorostictus*)	Pacific sanddab (*Citharichthys sordidus*)
greenstriped rockfish (*Sebastes elongatus*)	petrale sole (*Eopsetta jordani*)
Pacific ocean perch (*Sebastes alutus*)	rex sole (*Glyptocephalus zachirus*)
quillback rockfish (*Sebastes maliger*)	rock sole (*Lepidopsetta bilineata*)
redbanded rockfish (*Sebastes babcocki*)	sand sole (*Psettichthys melanostictus*)
redstripe rockfish (*Sebastes proriger*)	starry flounder (*Platichthys stellatus*)

Sources: Casillas et al. (1998) and Hart (1973).

Pelagic Species

Coastal pelagic species (CPS) are schooling fish that are not associated with the ocean bottom, but migrate in coastal waters. The CPS fishery includes four finfish: Pacific sardine (*Sardinops sagax*), Pacific (chub) mackerel (*Scomber japonicus*), northern anchovy (*Engraulis mordax*), and jack mackerel (*Trachurus symmetricus*) and the invertebrate, market squid (*Loligo opalescens*) (NMFS 1998b). CPS finfish are pelagic (in the water column near the surface and thus not associated with particular substrate) because they generally occur above the thermocline in the upper mixed layer. For the purposes of defining EFH, NOAA Fisheries has treated the four CPS finfish as a single species complex because of similarities in their life histories and similarities in their habitat requirements (NMFS 1999b). Market squid are included in this complex because they are similarly fished above spawning aggregations. However, of these species, only market squid are found in Puget Sound in sufficient numbers that they are routinely harvested.

Market squid are short-lived molluscs with adults reaching a maximum size of 30 cm total length (including arms). Market squid appear to live to less than one year. Like northern anchovy and Pacific sardine, market squid are probably forage to many fish, bird, and marine mammal predators. Peak commercial catches occur in the late summer from Oregon to Alaska. Market squid spawn in Puget Sound in shallow subtidal water attaching their egg cases to essentially any hard object, often in areas of silt to sand substrate.

Sardines are small schooling fish that inhabit coastal subtropical and temperate waters. During times of high abundance, Pacific sardine range from the tip of Baja California to southeastern Alaska. When abundance is low, Pacific sardine do not occur in commercially fishable quantities north of Point Conception, California. Juvenile and adult sardine are consumed by an assortment of fish, seabirds, and marine mammals.

Pacific mackerel in the northeastern Pacific range from Banderas Bay, Mexico to southeastern Alaska. Pacific mackerel larvae are eaten by many invertebrate and vertebrate planktivores. Larger fish, marine mammals, and seabirds prey upon adult and juvenile Pacific mackerel.

The central subpopulation of northern anchovy ranges from San Francisco, California to Punta Baja, Mexico. Northern anchovy are subject to predation in all of their life stages by numerous marine fishes, mammals, and birds.

Jack mackerel are a pelagic schooling fish that ranges widely throughout the northeastern Pacific. Much of their range lies outside the 200-mile U.S. exclusive economic zone. Jack mackerel sampled off Oregon and Washington ranged from 30 to 62 cm in length and from 4 to 35 years old (Nebenzahl 1997). Large predators like tuna and billfish prey on jack mackerel. Smaller predators may consume young-of-the-year and yearling jack mackerel.

NMFS (1999b) has defined the east-west geographic boundary of EFH for CPS market squid and finfish as all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the exclusive economic zone and above the thermocline where sea surface temperatures range between 10 to 26°C. The southern extent of EFH for CPS finfish is the United States-Mexico maritime boundary. The northern boundary of the range of CPS finfish is more dynamic and variable due to the seasonal cooling of the sea surface temperature. The seasonally and annually variable northern EFH boundary is the position of the 10°C isotherm.

Each of the four fish (northern anchovy, Pacific sardine, jack mackerel, and Pacific mackerel) have been observed in the coastal waters of Washington State, central Puget Sound, or the Strait of Juan de Fuca. However, only three have been observed within Puget Sound, and there may be some EFH in the project area for these three species (adapted from NMFS 1998b) (Exhibit 4-6). Any EFH for these species in the project area will include water and substrate necessary to their life cycle. Although small numbers may occasionally be observed in Puget Sound they are not likely to rely on substrate or the water column along the seawall for living space and are not known to reproduce in this habitat.

Exhibit 4-6. Summary of Distribution and Essential Fish Habitat for Pacific CPS in the Coastal Waters of Washington State and in the Project Area

Common Name Life-stage	Present in Coastal Waters of Washington State	Present in Action Area
Northern Anchovy		
eggs/larvae/ juveniles	yes	unlikely
adults	yes	unlikely
Pacific Sardine		
eggs/larvae/ juveniles	yes (restricted to seasonally warm thermocline)	unlikely
adults	yes (restricted to seasonally warm thermocline)	unlikely
Pacific (Chub) Mackerel		
eggs/larvae/ juveniles	yes (restricted to seasonally warm thermocline)	unlikely
adults	yes (restricted to seasonally warm thermocline)	unlikely
Jack Mackerel		
eggs/larvae/ juveniles	no	no
adults	yes	no
Market Squid		
eggs/larvae/ juveniles	yes	yes
adults	yes	yes

Source: NMFS (1998b).

4.1.4 Marine Invertebrates

The intertidal and shallow subtidal habitat along the seawall is occupied by the normal range of invertebrates commonly observed in similar areas of Puget Sound based on the visual observations of the diver survey conducted for the project and information contained in Taylor (1995). Video records show that red crabs (*Cancer productus*), hairy crabs (*Telmessus cheiragonus*), coon-stripe shrimp (*Pandalus danae*), starfish (*Evasterias trochelei*, *Pisaster brevispinus*), and anemones (*Metridium senile*) are commonly observed larger invertebrates. The giant Pacific octopus (*Octopus dolfeini*) is occasionally found under piers, and the Seattle Aquarium releases several annually under the Aquarium pier. Adults may reside and reproduce in suitable areas where they can find holes providing adequate protection. A wide variety of small invertebrates are common on the macroalgae and open substrate, but were not identified for this project.

4.1.5 Wildlife

The urban habitat provided by the highly developed shoreline of the Alaskan Way Seawall and Alaskan Way Viaduct provides support only for those species highly adapted to intense human activity and totally modified environments. The existing buildings, sidewalks, streets, and parking lots cover nearly all the project site. A few street trees (trees within planting strips and other landscaped areas along the roadways) and shrubs in small planting areas provide the only approximation of natural habitat supporting wildlife. Both mammals and birds of a variety of species use these urban habitats.

Mammals

Mammalian species potentially found in the sparse vegetation and highly urbanized habitat along the Seattle shoreline and the Alaskan Way Viaduct Corridor include those listed in Exhibit 4-7. Marine mammal species that occur along Elliott Bay's Seattle shoreline include harbor seal (*Phoca vitulina*) and California sea lion (*Zalophus californianus*). These marine mammals feed on flatfish, rockfish, cod, squid, and octopus. They occasionally feed on salmon (adult and juvenile), although salmon are not a major part of their diet (Osborne et al. 1988). Harbor seals have been reported to feed on juvenile salmon (Olesiuk et al. 1995; Yurk and Trites 2000). Orcas, gray whales, and Dall's porpoise occasionally occur within Elliott Bay, but are not observed close to the urban shoreline.

Common Avifauna

Birds potentially found in the urban habitat along the Alaskan Way Viaduct Corridor include those listed in Exhibit 4-8. These birds potentially use the street trees for roosting, feeding, and possibly nesting. Many commonly feed on the ground and along streets in urban areas. However, scattered street trees within highly developed areas provide minimal habitat for any of these species.

Exhibit 4-7. Mammals That May Occur Within Urban Habitat Along the Alaskan Way Viaduct Corridor

Common Name	Scientific Name	Common Name	Scientific Name
common opossum	*Didelphis marsupidlis*	muskrat	*Ondatra zibethicus*
little brown myotis	*Myotis lucifugus*	house mouse	*Mus musculus*
Yuma myotis	*Myotis yumanensis*	Pacific jumping mouse	*Zapus trimtatus*
California myotis	*Myotis califomicus*	Norway rat	*Rattus norvegicus*
silver-haired bat	*Lasionycteris nociivagans*	black rat	*Rattus rattus*
big brown bat	*Eptesicus fuscus*	coyote	*Canis latrans*
hoary bat	*Lasiurus cinereus*	raccoon	*Procyon lotor*
Townsend's big-eared bat	*Plecotus townsendii*	ermine	*Mustela erminea*
long-eared myotis	*Myotis evotis*	mink	*Mustela vison*
domestic rabbit	*Oryctolagns cuniculus*	river otter	*Lutra canadensis*
eastern gray squirrel	*Sciurus carolinensis*	domestic dog	*Canis familiaris*
deer mouse	*Peromyscus maniculatus*	domestic cat	*Felis domesticus*

Exhibit 4-8. Birds Commonly Found in Moderately and Poorly Vegetated Urban Habitats of Seattle

Glaucous winged gull	Bewick’s wren	black-headed grosbeak	golden-crowned kinglet
rock dove	ruby-crowned kinglet	evening grosbeak	dark-eyed junco
Anna’s hummingbird	American robin	rufous-sided towhee	bushtit
northern flicker	Bohemian waxwing	fox sparrow	northern oriole
downey woodpecker	cedar waxwing	song sparrow	red-breasted nuthatch
Steller’s jay	yellow-rumped warbler	golden-crowned sparrow	violet-green swallow
American crow	spotted towhee	white-crowned sparrow	European starling
black-capped chickadee	winter wren	house sparrow	
chestnut-backed chickadee	Wilson’s warbler	house finch	

Raptors

Raptors observed along the Alaskan Way Viaduct and Alaskan Way Seawall project area include ospreys, peregrine falcons, and bald eagles. Ospreys may be found foraging along Seattle's waterways, including the Elliott Bay shoreline. However, the closest known osprey breeding territory along the alternative alignments is about ½ mile from the southern end of the corridor (Noble 2002 personal communication). This osprey nest is located at the Heron's House habitat restoration project on the lower Duwamish River. There is a peregrine falcon aerie on the top of one of the high-rise buildings within several blocks of the Alaskan Way Viaduct in downtown Seattle. Osprey and peregrine falcon habitat will not be substantively altered by the project.

Bald eagles are present within the City of Seattle nesting in various substantial patches of trees such as Discovery Park in the Magnolia area and the greenbelt along the west side of the lower Duwamish River and feeding along the Elliott Bay shorelines. Within the Alaskan Way Viaduct project area, only foraging habitat along the seawall is likely to be used by bald eagles. Nesting, foraging, and perching habitat for bald eagles is typically associated with water features such as rivers, lakes, and coast shorelines where eagles prey upon fish, waterfowl, and seabirds (Stalmaster 1980, 1983, 1987). During the breeding season, eagles establish and maintain territorial boundaries, and breeding birds will rarely be found in high numbers. Breeding eagles show strong fidelity to a particular nesting territory, and will prevent other eagles from entering it (Grubb 1980). Territories frequently contain two or more nests, but are used exclusively by one breeding pair, thereby reducing competition for local food resources. Although bald eagles use only one nest in a given year, they may alternate between a number of nests found in their territory between years (Stalmaster and Newman 1979).

Priority Habitats and Species (PHS) data from Washington Department of Fish and Wildlife (WDFW) did not indicate any nesting bald eagle within 0.5 mile of the project area. The nearest nesting territory is in the greenbelt west of the lower Duwamish River beyond the 0.25- to 0.4-mile distance within which researchers have found nesting eagles to react to potentially disturbing activities (Fraser et al. 1985; Anthony and Isaacs 1989; Grubb and King 1991; Parson 1994).

Bald eagles may spend nights together in communal roosts, more commonly in winter and extreme weather. The winter period for bald eagles is from October 31 through March 31. Many roosts are traditional sites that are used repeatedly and are typically located in areas where the eagles have protection from the weather, and away from human activity (Hansen et al. 1980). PHS data do not indicate any roost sites near the project.

Bald eagles were first protected by the Bald Eagle Protection Act of 1940 and later listed as endangered under the Endangered Species Act of 1973. In 1978, the eagle was reclassified as threatened in five states, including Washington. The continental U.S. population of bald eagles has since made a dramatic recovery. Because of this recovery, USFWS has proposed that the bald eagle be delisted (USFWS 1999b). Recovery has been dramatic in Washington State, where there are now over 600 nesting pairs, with approximately 300 pairs in Puget Sound alone. Bald eagle nesting territories are now found along much of the shorelines of Puget Sound and Lake Washington. Washington State also supports the largest wintering (December through March) population of bald eagles in the continental U.S. A few thousand birds can be found throughout the state where waterfowl and fish congregate, including along the shorelines of Puget Sound.

Waterfowl

A variety of waterfowl use the nearshore habitat of Elliott Bay, including the Seattle shoreline (Exhibit 4-9). Many of these species are only occasional or seasonal visitors to the shoreline area, while others (such as several of the gulls) are nearly always present.

Exhibit 4-9. Waterfowl and Water-Related Birds Potentially Found Along the Seattle Shoreline

common loon	double-crested cormorant	common goldeneye	herring gull
yellow-billed loon	Brandt's cormorant	bufflehead	California gull
Pacific loon	pelagic cormorant	American coot	western gull
red-throated loon	greater scaup	hooded merganser	Bonaparte's gull
western grebe	lesser scaup	red-breasted merganser	ring-billed gull
red-necked grebe	black scoter	pigeon guillemot	mew gull
horned grebe	surf scoter	belted kingfisher	
eared grebe	white-winged scoter	great blue heron	

4.1.6 Vegetation

Vegetation potentially affected by the Alaskan Way Seawall and Alaskan Way Viaduct replacement or repair includes both marine macrophytes (algae) and riparian vegetation. Most of the potentially affected vegetation is the shallow subtidal community of marine macrophytes that occupy the larger open water areas along the seawall. This community is composed of a variety of green, red and brown algae commonly found in shallow subtidal areas of Puget Sound. Species of algae observed in the shallow subtidal habitat of the larger open areas along the Alaskan Way Seawall are listed in Exhibit 4-10. The bottom of the larger open water areas at the base of the seawall to depths of about 30 ft are essentially covered with these algal species where sufficient large gravel and cobble size material or debris is present on the sediment surface.

Exhibit 4-10. Species of Marine Macrophytes (Algae) Observed Along the Seattle Waterfront

Type/Common Name	Scientific Name	Occurrence
Green Algae		
sea hair	*Enteromorpha intestinalis*	common
sea lettuce	*Ulva fenestrata*	common
sea cellophane	*Monostroma grevillei*	common
Red Algae		
crisscross network	*Polyneura latissima*	common
red ribbon	*Palmaria mollis (palmata)*	common
bull-kelp laver	*Porphyra Nereocystis*	common
turkish towel	*Chondracantbus exasperatus*	common
splendid iridescent seaweed	*Mazzaella splendens*	common
winged rib	*Delesseria decipiens*	occasional
violet sea fan	*Callophyllis violacea*	occasional
turkish washcloth	*Mastocarpus papillatus*	occasional
sea spaghetti	*Gracilaria sjoesttedtii* or *pacifica*	occasional
Brown Algae		
sugar kelp	*Laminaria saccharina*	common
wireweed	*Sargassum muticum*	common
seersucker	*Costaria costata*	common
rockweed	*Fucus gardneri (distichus)*	common
ribbon kelp	*Alaria marginat*	common
bull kelp	*Nereocystis luetkeana*	occasional

Source: Data recorded by Parametrix dive survey conducted by Don Weitkamp, David Gillingham, Bill Peters, June 4 and 5, 2002.

Riparian vegetation in the project vicinity is sparse or absent. A few street trees have been planted along the edges of Alaskan Way, landward of the seawall. Trees are generally absent in the riparian zone along the Alaskan Way Seawall.

4.2 South – S. Spokane Street to S. King Street

This upland portion of the Alaskan Way Viaduct project area has no fish and very little wildlife and vegetation resources. A few street trees and urban wildlife compatible with a man-made industrial habitat are present. Mammals and birds potentially found in the project area are listed in Exhibits 4-7 and 4-8.

4.3 Central – S. King Street to Battery Street Tunnel

This upland portion of the Alaskan Way Viaduct project area has no fish and very little wildlife and vegetation resources. A few street trees and urban wildlife compatible with a man-made industrial habitat are present. Mammals and birds potentially found in the project area are listed in Exhibits 4-7 and 4-8.

4.4 North Waterfront – Pike Street to Myrtle Edwards Park

This upland portion of the Alaskan Way Viaduct project area has no fish and very little wildlife and vegetation resources. A few street trees and urban wildlife compatible with a man-made industrial habitat are present. The seawall portion of the segment has all of the aquatic resources described in Section 4.1.

4.5 North – Battery Street Tunnel to Ward Street

This upland portion of the Alaskan Way Viaduct project area has no fish and very little wildlife and vegetation resources. A few street trees and urban wildlife compatible with a man-made industrial habitat are present.

4.6 Seawall – S. King Street to Myrtle Edwards Park

All of the aquatic resources described in Section 4.1 are present within this and the north waterfront portions of the project site. The wildlife and vegetation resources described above are also present along this and the north waterfront portions of the project site, including the aquatic resources that are potentially present seaward of the Alaskan Way Seawall.

Chapter 5 OPERATIONAL IMPACTS AND BENEFITS

Potential impacts associated with the Alaskan Way Viaduct and Seawall Replacement Project are identified along the project corridor for each alternative (see Appendix B, Alternatives Description and Construction Methods Technical Memorandum for detailed descriptions). Operational impacts and benefits will be produced by the potential changes to the physical characteristics of habitat along the Alaskan Way Viaduct Corridor together with the potential changes to water quality with the various alternatives. Potential impacts to the various species likely using the shoreline and shallow water habitat along the Alaskan Way Seawall were evaluated. Because fish, wildlife, and vegetation resources potentially affected by each of the alternatives are primarily associated with the Alaskan Way Seawall, other segments of the project are not discussed in the following evaluations.

The analysis evaluates two proposed seawall replacement alternatives (Rebuild and Tunnel) and one option (Frame).

The Rebuild Alternative will construct a new concrete seawall landward of the existing seawall throughout most of its length. The seawall site covers a little more than 7,100 ft of shoreline from the north side of Pier 48 to Myrtle Edwards Park. The Rebuild Alternative will construct a new seawall by adding drilled shafts, and will include strengthening the weak soils behind the seawall by jet grouting. Jet grouting stabilizes soils by injecting and mixing cement grout into in-situ soils to produce structurally more competent soil. Jet grouting will produce a solid block of strengthened soil behind the existing seawall.

The tunnel alternatives will use the western tunnel wall as a new seawall. Construction will replace the seawall with a secant pile wall. This seawall replacement structure will extend from approximately S. King Street (south end of tunnel) to near the north tunnel end at Pike Street. Existing seawall sheet pile will be removed or cut off at or below the mud line. Sheet pile supporting the fill between Pier 48 and the Washington Street Boat Landing will be replaced.

The Frame option would replace the seawall with a structural frame. The frame would consist of a continuous secant pile wall (new type of seawall) constructed behind the existing seawall and a landside bulkhead constructed to the east. The secant pile wall is a series of overlapping drilled shafts filled with concrete to form a solid wall. The landside bulkhead would be connected by a concrete beam with up to 15 ft of fill on the top.

Impacts to the shoreline habitat tend to be the same over most of the Seattle waterfront for each alternative except for the No Build Alternative. Generally, the impacts are identical for each alternative for the seawall area from Colman Dock north to Myrtle Edwards Park. Differences are described among the alternatives that will occur for the portion of the seawall between Pier 48 and Colman Dock. Exhibit 5-1 summarizes the changes in shoreline habitat that will occur with each of the alternatives evaluated and the Frame option to the Aerial Alternative. Most replacement alternatives will increase the volume and intertidal surface area of Elliott Bay as listed in Exhibit 5-1 by removing the existing seawall following construction of a new seawall on the land side (Exhibit 5-2). The new area will be intertidal riprap along the base of the new seawall. With each of the Build Alternatives, a portion of the existing shallow subtidal area described in Section 4.1.1 will be covered by a new pier structure providing a roadway connection to Colman Dock (see description of Access Roadway to Colman Dock in Section 2.2.3 of Appendix B). With the tunnel alternatives, the existing intertidal area and a portion of the subtidal area will be filled by the tunnel and new seawall structure.

The nature of the physical changes to the shoreline at the seawall is shown in Exhibit 5-2. This illustration shows cross sections of the general characteristics of each seawall type that will change with the various Build Alternatives.

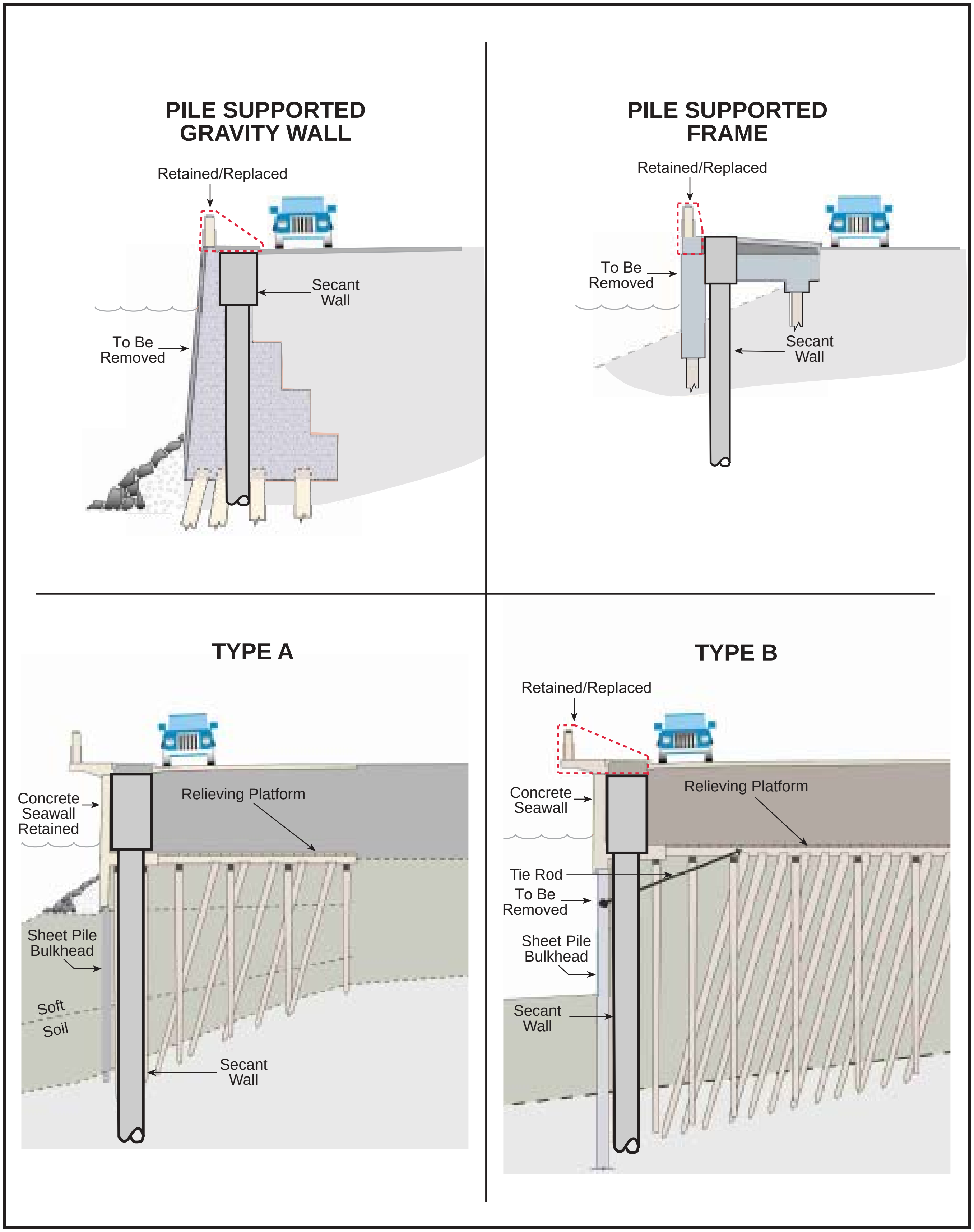
Information was compiled from existing sources that provides the basis for the impacts analysis and later for identification of an Action Area. Analysis of impacts is required for both the Environmental Impact Statement (EIS) and a Biological Assessment (BA), and identification of an Action Area is required for a BA. This information also provides the basis for assessing the direct, cumulative, and indirect impacts of project alternatives.

Analysis of Essential Fish Habitat (EFH) involves identification of species potentially occurring within the project area and the habitat characteristics important to these species (Section 4.1.3, Essential Fish Habitat). The analysis identifies the EFH habitat potentially altered by the project alternatives. EFH has been defined for the purposes of the Magnuson-Stevens Act as "*those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity*" (NMFS 1999b). The EFH analysis will be included in the BA.

Impacts the seawall alternatives may have on the habitat characteristics and biota of the shoreline environment are assessed and described for each alternative for inclusion in the Draft EIS and the BA. Agency and public comments may raise additional issues that will require additional analyses and evaluation of impacts not included in the Draft EIS or BA. Additional information may be gathered and reviewed to address these issues.

Exhibit 5-1. Amounts of Shoreline Habitat Changes for Each Seawall Replacement Alternative

	Elliott Bay		Pier 48 to Colman Dock	
Alternative	Volume (yd^3)	Area (ft^2) –4 to +6 ft MLLW	New Shaded Area (ft^2)	Fill (ft^2)
No Build	Unknown	Unknown	Unknown	Unknown
Rebuild	+ 7,978	+10 to +4: 12,730 +4 to 0: 3,640 0 to -4: 0 -4 to -10: 6,180 > -10: 0 total: 22,550	+10 to +4: 0 +4 to 0: 2,100 0 to -4: 5,540 -4 to -10: 15,590 > -10: 11,970 total: 35,200	+10 to +4: -12,730 +4 to 0: -3,640 0 to -4: 0 -4 to -10: -6,180 > -10: 0 total: -22,550
Aerial	+ 7,978	+10 to +4: 12,730 +4 to 0: 3,640 0 to -4: 0 -4 to -10: 6,180 > -10: 0 total: 22,550	+10 to +4: 0 +4 to 0: 2,100 0 to -4: 5,540 -4 to -10: 15,590 > -10: 11,970 total: 35,200	+10 to +4: -12,730 +4 to 0: -3,640 0 to -4: 0 -4 to -10: -6,180 > -10: 0 total: -22,550
Aerial – Frame Option	+ 8,332	+10 to +4: 17,190 +4 to 0: 3,640 0 to -4: 0 -4 to -10: 6,180 > -10: 0 total: 27,010	+10 to +4: 0 +4 to 0: 2,100 0 to -4: 5,540 -4 to -10: 15,590 > -10: 11,970 total: 35,200	+10 to +4: -17,190 +4 to 0: -3,640 0 to -4: 0 -4 to -10: -6,180 > -10: 0 total: -27,010
Tunnel	+ 6,211	+10 to +4: 0 +4 to 0: -1,181 0 to -4: -1,657 -4 to -10: -862 > -10: 0 total: -3,700	+10 to +4: 0 +4 to 0: 1,100 0 to -4: 4,650 -4 to -10: 13,780 > -10: 11,970 total: 31,500	+10 to +4: 0 +4 to 0: 1,181 0 to -4: 1,657 -4 to -10: -862 > -10: 0 total: 3,700
Bypass Tunnel	-5,094	+10 to +4: 0 +4 to 0: -1,690 0 to -4: -6,330 -4 to -10: -5,970 > -10: -910 total: -14,900	+10 to +4: 0 +4 to 0: 0 0 to -4: 0 -4 to -10: 9,5500 > -10: 10,750 total: 20,300	+10 to +4: 0 +4 to 0: 1,690 0 to -4: 6,330 -4 to -10: -5,970 > -10: 910 total: 14,900
Surface	+ 7,978	+10 to +4: 12,730 +4 to 0: 3,640 0 to -4: 0 -4 to -10: 6,180 > -10: 0 total: 22,550	+10 to +4: +4 to 0: 0 to -4: -4 to -10: > -10: total: 35,200	+10 to +4: 12,730 +4 to 0: 3,640 0 to -4: 0 -4 to -10: 6,180 > -10: 0 total: 22,550



Source: Berger/Abam Engineers, Inc.

NOT TO SCALE

Exhibit 5-2
Cross Sections Showing Changes to Basic Physical Characteristics of Alaskan Way Seawall Types

With all Build Alternatives, the existing seawall will be replaced with a new seawall constructed landward of the existing seawall with a sidewalk cantilevered over the new aquatic habitat area. This new seawall will extend along most of the seawall length from Colman Dock north to Myrtle Edwards Park. In the area between Pier 48 and Colman Dock, new over-water cover will be added by an access roadway built to connect the existing or expanded Colman Dock pier to a ferry holding area on Terminal 46. A portion of this area between Pier 48 and Colman Dock will be filled with the Tunnel and Bypass Tunnel Alternatives. With all Build Alternatives, changes to the stormwater collection and treatment systems will be made (see Appendix S, Water Resources Discipline Report) to improve existing conditions, avoiding any long-term impacts to aquatic resources.

5.1 No Build Alternative

Initially no change to existing conditions will occur with this alternative. The existing seawall will remain in place with routine maintenance occurring as required. Routine maintenance will not measurably change conditions for fish, wildlife, and vegetation resources, although localized disturbances of biota on and immediately adjacent to the seawall may occur at times.

All marine biota at the locations of the future actions or failures with the No Build scenarios will be either displaced or destroyed. Large motile biota such as fish and some crabs will likely leave the area of the action or failure. Most invertebrates and algae along with some of the fish will likely be destroyed. Loss of fish is more likely with the catastrophic failure of portions of the seawall (Scenarios 2 and 3) than with the continued maintenance (Scenario 1).

With each of the following three No Build scenarios, fish, wildlife, and vegetation resources along the Seattle shoreline will be affected by physical alterations to the basic habitat. Shoreline habitat supporting juvenile Chinook salmon (ESA listed species) will be altered. Impacts to EFH will be similar with alterations to existing intertidal and shallow subtidal portions of the shoreline. The baseline EFH information is described in Chapter 4, Affected Environment. The amount and degree of changes to aquatic habitat have not been predicted. As future planning results or the date and degree of failure of the seawall cannot be predicted, the amounts of probable change in fill and shaded area that will occur at some unidentified time in the future cannot be predicted.

5.1.1 Scenario 1 – Continued Operation of the Viaduct and Seawall With Continued Maintenance

Existing conditions will remain for the foreseeable future with continued maintenance of the seawall and viaduct. Improvements to stormwater discharges to Elliott Bay will occur as planned and will be developed independently from the Alaskan Way Viaduct and Seawall Replacement Project.

5.1.2 Scenario 2 – Sudden Unplanned Loss of the Viaduct and/or Seawall but Without Major Collapse or Injury

It is assumed the damaged portions (undefined amounts and locations) of the seawall and viaduct will be replaced with the sudden loss of a portion of the seawall or roadway. Stormwater facilities will be retrofitted with stormwater BMPs in accordance with the WSDOT Stormwater Manual (WSDOT 1995). Potential impacts and benefits associated with Scenario 2 are not evaluated because the location, degree of habitat alteration, and nature of restoration cannot be defined prior to the event causing loss of the facilities.

5.1.3 Scenario 3 – Catastrophic Failure and Collapse of the Viaduct and/or Seawall

Sudden collapse of the seawall will result in catastrophic modification of the shoreline at the location(s) of the collapse. The concrete seawall, fill material, and potentially other structures will be deposited in shallow water along the shoreline. Ruptures of water and sewer lines will result in washing of additional material and sewage into Elliott Bay. It is probable that stormwater and untreated sewage will be discharged directly to Elliott Bay at various locations. Fuel tanks and other sources of contamination along the waterfront will also likely be damaged and release contaminants to Elliott Bay. Existing fish habitat and algae will be destroyed at the location of the failure(s). Impacts of operation will depend on the action selected to remove materials lost to Elliott Bay by the failure.

Emergency repairs to the damaged areas will likely result in a new seawall constructed over a period of months to years with standard BMPs to protect water quality. No actions to restore habitat functions are likely to be included in emergency replacement of the damaged seawall sections. Subsequent to the emergency actions, the City of Seattle will likely require actions to mitigate the effects of the emergency action.

5.2 Rebuild Alternative

The Rebuild Alternative will replace much of the existing seawall from Pier 48 to Myrtle Edwards Park with a new seawall on the land side of the existing wall. Essentially all habitat modifications that will occur with the Rebuild Alternative will be produced by reconstruction of the Alaskan Way Seawall and the following removal of the existing seawall. Along other segments of the Alaskan Way Viaduct, the urban habitat of streets, sidewalks, and buildings will be demolished and replaced with similar structures. See Appendix W, Exhibits R19 though R22 for specific seawall segments.

Rebuilding the seawall from Pier 48 to Myrtle Edwards Park will produce modified habitat, including both new over-water cover in an existing open-water area (Pier 48-Colman Dock) and new aquatic habitat in existing fill areas (shoreline Colman Dock to Myrtle Edwards Park). The total volume of aquatic habitat in Elliott Bay will increase by an estimated 7,978 yd^3 with this alternative. The increased amount of aquatic habitat will result from removal of portions of the existing seawall following construction of a new seawall landward of the existing location. Riprap protecting the intertidal and shallow subtidal base of the reconstructed seawall will be replaced, extending slightly landward from its original location.

With the Rebuild Alternative, the existing seawall will be replaced with a new landward seawall. The existing cantilevered sidewalk will be replaced over the new aquatic habitat area (existing seawall location) along most of the seawall length from Colman Dock north to Myrtle Edwards Park. This continued shading of the seawall would likely continue to limit the growth of macroalgae on the lower intertidal portions of the seawall and riprap. A new over-water pier will be added between Pier 48 and Colman Dock by the roadway connecting the existing or rebuilt ferry pier to the new ferry holding area on existing Terminal 46. With each build alternative, a shoreline area between Pier 48 and Colman Dock of 35,200 ft^2 will be modified. The intertidal shoreline and shallow subtidal habitat of this area will be covered by a new pier connecting Pier 48 to Colman Dock Ferry Terminal with the Rebuild Alternative. This change will likely eliminate production of macro algae in most or all of the additional 32,940 ft^2 of shaded area between Pier 48 and Colman Dock. Loss of the macroalgae will reduce the quality of the habitat making in undesirable for many of the fish and macroinvertebrates that currently area found at the site.

Fish, invertebrates, and algae currently inhabiting the intertidal and shallow subtidal habitat along the Seattle waterfront will likely continue to inhabit the same areas. The expansion of Elliott Bay by 7,978 yd^3 will provide additional intertidal living space for production of slightly more planktonic and pelagic organisms. The additional riprap habitat will provide additional living space for hard substrate invertebrates such as barnacles, tube worms, etc. and fishes associated with riprap such as sculpins, shiner perch, etc.

Water quality of the shoreline habitat will improve somewhat with the Rebuild Alternative. The quantity of stormwater discharged to the Seattle waterfront will remain unchanged, but some improvements in stormwater treatment will occur as part of the Alaskan Way Viaduct rebuild (see Appendix S, Water Resources Discipline Report). Stormwater currently discharging directly into Elliott Bay in the 35,200-ft^2 area between Pier 48 and Colman Dock will be collected and treated with the BMP Approach.

Concentrations of metals and PAHs in the stormwater discharged along the shoreline will either decrease or remain unchanged.

5.3 Aerial Alternative

The proposed action for the seawall with the Aerial Alternative is the same as for the Rebuild Alternative. The existing seawall would be replaced from Pier 48 to Myrtle Edwards Park with a new seawall on the land side of the existing wall. However, there is also a Seawall Frame option. With the Aerial Alternative, the actions and impacts would be the same as for the Rebuild Alternative. The action and impacts would be slightly different with the Seawall Frame option. This alternative would replace the existing Alaskan Way Viaduct with a new viaduct.

The Aerial Alternative will replace the existing seawall with a new landward seawall and a sidewalk cantilevered over the new aquatic habitat area along most of the seawall length from Colman Dock north to Myrtle Edwards Park. Between Pier 48 and the Colman Dock, new over-water cover (32,940 ft^2) will be added by the roadway connecting the existing or rebuilt ferry pier to the new ferry holding area on existing Terminal 46.

The Aerial Alternative Frame option would include rebuilding the seawall from Pier 48 to Myrtle Edwards Park, producing modified habitat, including both new fill in existing water areas and new aquatic habitat in existing fill areas (existing seawall location). See Appendix W, Exhibits A29 through A32 for specific seawall segments. The total volume of aquatic habitat in Elliott Bay would increase by an estimated 8,332 yd^3, slightly more than with the seawall Rebuild Alternative. The increased amount of aquatic habitat would result from removal of portions of the existing seawall following construction of a new seawall landward of the existing location. More material would be removed at the existing Pile-Supported Gravity Seawall area with the Frame option than with the rebuilt seawall. New fill would be a combination of replaced riprap and new riprap protecting the intertidal and shallow subtidal base of the reconstructed seawall. New riprap would extend the moderate slope to a higher intertidal elevation than currently exists with the vertical seawall at some locations. This would be considered a project benefit as the moderately sloped intertidal shoreline would be available at higher tidal elevations than with the existing seawall.

Water quality of the shoreline habitat will improve somewhat with the Aerial Alternative. The quantity of stormwater discharged to the Seattle waterfront will remain unchanged, but improvement in stormwater quality will occur as part of the Alaskan Way Viaduct replacement (see Appendix S, Water Resources Discipline Report). Improvement of stormwater quality will be slightly greater than with the Rebuild Alternative. Stormwater currently falling directly into Elliott Bay in the 35,200-ft^2 area between Pier 48 and Colman Dock will be collected and treated with the BMP Approach.

Biota currently inhabiting the intertidal and shallow subtidal habitat along the Seattle waterfront will likely continue to inhabit the same areas. The expansion of Elliott Bay by 7,978 yd^3 will provide additional living space for production of slightly more planktonic and pelagic organisms. With the Seawall Frame option, the Elliott Bay volume would increase by 8,332 yd^3. Coverage of an additional 32,940 ft^2 of shallow subtidal area between Pier 48 and Colman Dock will essentially eliminate algal production in the covered area, based on the existing absence of algae under the edge of Colman Dock.

5.4 Tunnel Alternative

The Tunnel Alternative is a side-by-side tunnel structure at a single level along the Seattle Waterfront. This alternative will replace the entire seawall from Colman Dock north to Myrtle Edwards Park (Exhibit 4-1). See Appendix W, Exhibits T26 through T29 for specific seawall segments. However, the amount of area involved and impacts to the habitat between Pier 48 and Colman Dock will be different.

Both the Tunnel Alternative and the Bypass Tunnel Alternative include rebuilding the seawall from Pier 48 to Myrtle Edwards Park, producing modified habitat, including both new fill in existing water areas and new aquatic habitat in existing fill areas (existing seawall locations).

The Side-by-Side Tunnel option would remove a portion of the shallow subtidal habitat between Pier 48 and Colman Dock, but return a portion of aquatic habitat north of Colman Dock by removal of the existing seawall. The total volume of aquatic habitat in Elliott Bay would increase by an estimated 6,211 yd^3, less than with the Aerial, Rebuild, and Surface Alternatives. This difference is the result of the tunnel extending into Elliott Bay along the shoreline between Pier 48 and Colman Dock. The increased amount of aquatic habitat would result from removal of portions of the existing seawall following construction of a new seawall landward of the existing location. New riprap would be placed to protect the intertidal and shallow subtidal base of the reconstructed seawall, adding new habitat to the Elliott Bay shoreline. New riprap would extend at a more moderate slope than currently exists. This would be considered a project benefit as the moderately sloped intertidal shoreline would be available at higher tidal elevations than with the existing seawall.

The Tunnel Alternative will replace the existing seawall with a new landward seawall and a sidewalk cantilevered over the new aquatic habitat area. The replaced seawall will extend along most of the existing seawall length from Colman Dock north to Myrtle Edwards Park. Between Pier 48 and Colman

Dock, the new seawall will be on the Elliott Bay side of the existing seawall along about 270 ft of shoreline (Exhibit 5-3). This area will have about 3,700 ft^2 of new fill on the water side of the existing seawall. The project would extend both the stormdrain and the combined sewer outfall at Washington Street to the edge of the new seawall.

An additional 29,240 ft^2 of Elliott Bay will be covered by a new roadway connection from Pier 48 to Colman Dock. This addition will alter a total of 35,200 ft^2 of shallow water habitat.

Water quality of the shoreline habitat will improve somewhat with the Tunnel Alternative. The quantity of stormwater discharged to the Seattle waterfront will remain unchanged, but improvement in stormwater quality will occur as part of the Alaskan Way Viaduct replacement (see Appendix S, Water Resources Discipline Report). Improvement of stormwater quality will be slightly greater than with the Rebuild Alternative. Concentrations of metals and PAHs in the stormwater discharged along the shoreline will either decrease or remain unchanged. Stormwater currently falling directly into Elliott Bay in the 35,200-ft^2 area between Pier 48 and Colman Dock will be collected and treated with the BMP method (see Appendix S, Water Resources Discipline Report).

Fish, invertebrates, and macroalgae currently inhabiting the intertidal and shallow subtidal habitat along the Seattle waterfront will likely continue to inhabit the same areas. The expansion of Elliott Bay by 6,211 yd^3 will provide additional living space for production of slightly more planktonic and pelagic organisms. Benthic habitat and the fish and invertebrates it supports will be eliminated from 3,700 ft^2 between Pier 48 and Colman Dock by the 3,700 ft^2 of shoreline fill. Coverage of an additional 31,500 ft^2 of shallow subtidal area between Pier 48 and Colman Dock will essentially eliminate algal production in the covered area, based on the existing absence of algae under the edge of Colman Dock.

5.5 Bypass Tunnel Alternative

The Bypass Tunnel Alternative is a single-level tunnel that will include rebuilding the seawall from Pier 48 to Myrtle Edwards Park. This rebuilt seawall will produce modified habitat, including both new fill in existing water areas and new aquatic habitat in existing fill areas (existing seawall location).

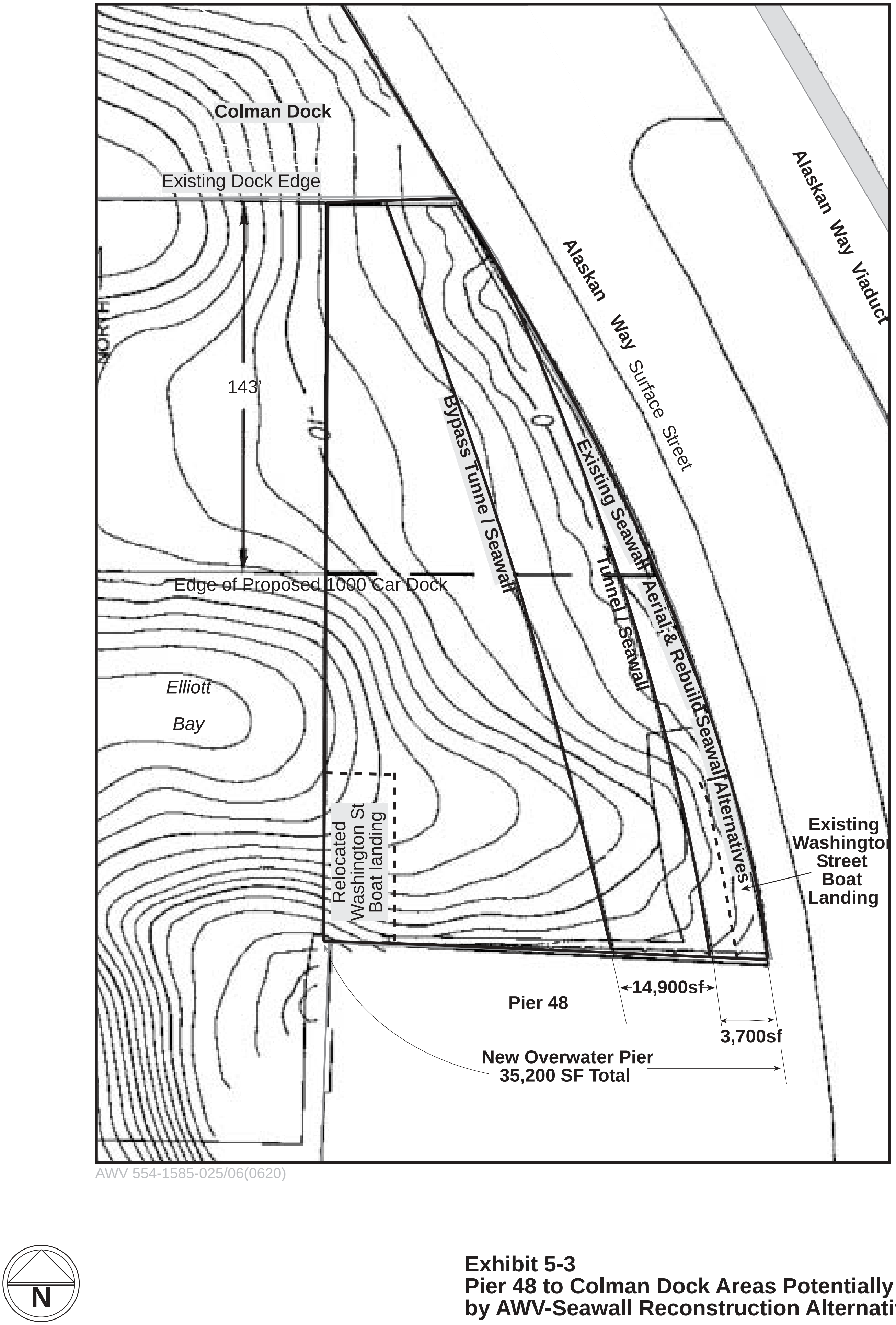


Exhibit 5-3
Pier 48 to Colman Dock Areas Potentially Altered by AWV-Seawall Reconstruction Alternatives

With the Bypass Tunnel Alternative, the total volume of aquatic habitat in Elliott Bay will decrease by an estimated 5,094 yd^3, rather than increase as with the other alternatives. The new seawall will be on the Elliott Bay side of the existing seawall along about 430 ft of shoreline (Exhibit 5-3), covering an intertidal and shallow subtidal area of about 14,000 ft^2. The decreased amount of aquatic habitat will result from the greater extension into Elliott Bay between Pier 48 and Colman Dock than with other alternatives. North of Colman Dock, portions of the existing seawall will be removed following construction of a new seawall landward of the existing location. New riprap will replace the existing riprap protecting the intertidal and shallow subtidal base of the reconstructed seawall, adding new habitat to the Elliott Bay shoreline. New riprap will be at a more moderate slope than the existing riprap, extending to a slightly landward location. This would be considered a project benefit as the moderately sloped intertidal shoreline would be available at higher tidal elevations than with the existing seawall.

The Bypass Tunnel Alternative will replace the existing seawall with a new landward seawall and a sidewalk cantilevered over the new water area along most of the seawall length from Colman Dock north to Myrtle Edwards Park. Between Pier 48 and the Colman Dock, 18,040 ft^2 of surface cover will be added to the 14,900 ft^2 of new fill, altering a total of 32,940 ft^2 of shallow water habitat. The roadway connecting the existing or rebuilt ferry pier to the new ferry holding area on existing Terminal 46 will add the over-water cover.

Water quality of the shoreline habitat will improve somewhat with the Bypass Tunnel Alternative. The project would extend both the stormdrain and the combined sewer outfall at Washington Street to the edge of the new seawall. The quantity of stormwater discharged to the Seattle waterfront will increase slightly as a result of new surface area between Pier 48 and Colman Dock. Improvements in stormwater quality will occur as part of the Alaskan Way Viaduct replacement (see Appendix S, Water Resources Discipline Report). Improvement of stormwater quality will be slightly greater than with the Rebuild Alternative. Stormwater currently falling directly into Elliott Bay in the 35,200-ft^2 area between Pier 48 and Colman Dock will be collected and treated with the Convey and Treat Approach.

Biota currently inhabiting the intertidal and shallow subtidal habitat along the Seattle waterfront will likely continue to inhabit the same areas. The reduction of Elliott Bay by 5,094 yd^3 will reduce living space in the bay, producing a slight reduction in planktonic and pelagic organisms. Benthic habitat and the fish and invertebrates it supports will be eliminated from 14,900 ft^2 between Pier 48 and Colman Dock. Coverage of an additional 20,300 ft^2 of shallow subtidal area between Pier 48 and Colman Dock will essentially eliminate algal production in the covered area, based on the existing absence of algae under the edge of Colman Dock.

5.6 Surface Alternative

The Surface Alternative will include rebuilding the seawall from Pier 48 to Myrtle Edwards Park, producing modified habitat, including both new fill in existing water areas and new water in existing fill areas (existing seawall location). See Appendix W, Exhibits S26 through S29 for specific seawall segments. The total volume of aquatic habitat in Elliott Bay will increase by an estimated 7,978 yd^3, the same as with the Rebuild and Aerial Alternatives. The increased amount of aquatic habitat will result from removal of portions of the existing seawall following construction of a new seawall landward of the existing location. New riprap will replace the existing riprap protecting the intertidal and shallow subtidal base of the reconstructed seawall. New riprap may extend the more moderate slope to a more landward location and a higher intertidal elevation than the existing riprap. Moderately sloped intertidal shoreline will be available at higher tidal elevations than with the existing seawall, which would be a project benefit.

The Surface Alternative will replace the existing seawall with a new landward seawall and a sidewalk cantilevered over the new aquatic habitat area along most of the seawall length from Colman Dock north to Myrtle Edwards Park. Between Pier 48 and the Colman Dock, new over-water cover (32,940 ft^2) will be added by the roadway connecting the existing or rebuilt ferry pier to the new ferry holding area on existing Terminal 46.

Water quality of the shoreline habitat will improve somewhat with the Surface Alternative. The quantity of stormwater discharged to the Seattle waterfront will remain unchanged, but improvement in stormwater quality will occur as part of the Alaskan Way Viaduct replacement (see Appendix S, Water Resources Discipline Report). Improvement of stormwater quality will be slightly greater than with the Rebuild Alternative. Stormwater currently falling directly into Elliott Bay in the 35,200-ft^2 area between Pier 48 and Colman Dock will be collected and treated with the Convey and Treat Approach.

Biota currently inhabiting the intertidal and shallow subtidal habitat along the Seattle waterfront will likely continue to inhabit the same areas. The expansion of Elliott Bay by 7,978 yd^3 will provide additional living space for production of slightly more planktonic and pelagic organisms. Coverage of an additional 32,940 ft^2 of shallow subtidal area between Pier 48 and Colman Dock will essentially eliminate algal production in the covered area, based on the existing absence of algae under the edge of Colman Dock.

5.7 Benefits

Benefits to the natural environment of the project area will result primarily from the improvements to intertidal and shallow subtidal habitat along the Seattle shoreline. The rebuilt seawall will increase, rather than decrease, the water area of Elliott Bay for the foreseeable future. Changes in basic habitat amounts are shown above in Exhibit 5-1. For all alternatives except the Bypass Tunnel, there will be an increase in the volume of Elliott Bay with new shallow subtidal and intertidal habitat along the shoreline. This increased volume will produce slightly more of the same fish, invertebrates, and algae that currently exist along the Seattle shoreline. Most likely a few more marine birds and shorebirds will be supported by this increased production. Because much of the new habitat will be shaded or partially shaded by an overhanging sidewalk, the new area will likely have limited macroalgae production. There will be an overall benefit to fish and wildlife habitat by replacing the seawall, which will remove the high risk of seawall failure and the subsequent severe impacts to habitat.

The risk of catastrophic failure of the seawall and resulting environmental damage to the shallow water habitat will be greatly reduced with the rebuilt seawall. These benefits that are provided by replacing the seawall will continue throughout the life of the project. Maintenance actions necessary to maintain the existing seawall produce local disruptions of the seawall habitat periodically. These maintenance actions will be greatly reduced by restoration of the structural support with the new seawall.

Chapter 6 CONSTRUCTION IMPACTS

Each of the Alaskan Way Seawall Build Alternatives will rebuild the existing seawall between Pier 48 (S. Washington Street) and Myrtle Edwards Park. Construction of the new seawall and removal of the existing seawall is anticipated to take approximately 36 months. The lengths of shoreline that could be disturbed by seawall replacement under each method are summarized in Exhibit 6.1. Also, the existing sheet pile wall adjacent to the base of Pier 48 at S. Washington Street will be replaced with the seawall replacement for all alternatives.

Construction methods used to build the new seawall will depend on the type and condition of the existing seawall. Potential temporary water quality impacts associated with each construction method are summarized in the following paragraphs. Existing vertical seawall and steeply sloped riprap along the intertidal shoreline will be replaced with the same habitat types with each alternative. With several alternatives, the intertidal riprap between Pier 48 and Colman Dock will be replaced with the tunnel and vertical seawall along either 270 ft or 430 ft of shoreline length.

Exhibit 6-1. Shoreline Lengths (ft) Disturbed With Seawall Replacement, All Alternatives

Rebuild Option Construction Method	Length of Potential Disturbed Shoreline (ft)		
	S. King Street to Virginia Street	Virginia Street to Battery Street	Battery Street to Myrtle Edwards Park
Pile-Supported Gravity Seawall	1,274	0	0
Type B Seawall	1,276	0	255
Type A Seawall	1,289	934	2,204

The new seawall will be constructed through a combination of secant pile walls and soil strengthening landward of the existing seawall. The drilled shaft secant pile wall will be constructed with the existing seawall in place, avoiding in-water work and loss of construction materials to the Seattle shoreline. Soil will be strengthened by jet grouting landward of the secant pile wall. Waste material generated by the soil grouting will be dewatered within the project site and water treated as required prior to discharge (see Appendix S, Water Resources Discipline Report).

Rebuilding the Pile-Supported Gravity Seawall will require removal of the existing seawall to the top of the existing piles on the waterside of the new seawall. Riprap protection of the shallow subtidal and intertidal slope will be replaced and extended within the new intertidal area to the new seawall. Jet grouting will occur behind the existing seawall to strengthen the soils. Jet grouting is the injection of grout into subsurface soil under high pressure to mix the grout and soil. Then the unreinforced concrete slab will be removed and replaced with sloping riprap material. Removal of the existing Pile-Supported Gravity Seawall and replacement of riprap will require in-water work that will temporarily disturb the sediment surface. Contaminated sediment will be disturbed as described in Appendix S, Water Resources Discipline Report. BMPs such as silt curtains or sheet pile walls could be implemented to minimize the potentially affected area. Replacement of the Pile-Supported Gravity Seawall will occur within a construction period of approximately 2 years.

Water currents in Elliott Bay along the waterfront are generally moderate to weak and run parallel to the waterfront at the end of the piers. Currents in Elliott Bay are generally insufficient to resuspend and transport its mud sediment (Curl et al. 1988). The benthic substrate along the Seattle Waterfront is predominately mud (McLaren and Ren 1994), with the net sediment transport to the south in a clockwise path. Between the perpendicular piers at the shoreline the currents tend to be weaker and of mixed direction. Therefore, it is assumed that any temporary increase in turbidity will be adjacent to the work area and will not have measurable off-site impacts.

Rebuilding the existing Type B Seawall will involve in-water work to remove the existing Ekki wood facing, cantilever, steel sheet pile, and jet grouting on the waterside of the new seawall. Soil behind the seawall will be strengthened through jet grouting. Following construction of the new seawall, the existing exposed sheet pile wall will be removed by cutting it off at or below the mud line. The work area will be below the water level, resulting in disturbance of sediment, and will potentially produce temporary impacts to water quality. Existing riprap will potentially be removed and may be replaced with new riprap within the intertidal zone following removal of the existing seawall. Implementation of BMPs, such as silt curtains, will localize and minimize potential impacts. Construction of the new seawall and removal of the existing Type B Seawall will require about 30 to 36 months.

Rebuilding the existing Type A Seawall will involve construction work landward of the existing seawall. No in-water work will be required for construction of the new seawall, as the existing seawall will remain in place following construction of the new seawall. Existing riprap will not be removed and replaced. No disruption of the sediment surface is anticipated during construction, including in the vicinity of the Seattle Aquarium.

Construction of new support for the existing Type A Seawall will require 30 to 36 months.

Replacing either seawall type for the Tunnel Alternatives and the Frame option may involve construction of a secant pile wall. The secant pile wall will be constructed of 4-ft-diameter drilled shafts extending up to 90 ft deep. These shafts will form a continuous wall from the south end of the tunnel near S. King Street to its north end near Pike Street. The secant pile wall will be constructed behind the existing Alaskan Way Seawall and will be both a seawall and the outer wall of the tunnel.

Excavated soil and demolition materials may be moved from the project area by truck, rail, or barge. One or more of these methods may also deliver construction materials. Only barge movement of materials has potential to affect the shoreline habitat. Barge movements will be similar to existing vessel movements along the shoreline and will not represent a new or different impact. Barge loading and unloading will occur at an existing facility, however, barges will not anchor over eelgrass beds if any are located in the area. Shoreline transfer and staging of materials could occur at Terminal 46, Pier 56, and Pier 62/63 if barge transport were employed.

Planned construction of the seawall will involve in-water work between July 15 and February 15 when migrating juvenile salmon are not likely to be present along the shoreline habitat. Small numbers of sub-adult and adult bull trout may be in the project vicinity during this period. However, eelgrass and concentrations of forage fish that appear to attract bull trout to Puget Sound shorelines are not present likely to be present along the urbanized seawall shoreline where the work will occur. If individual bull trout are present in the vicinity, they are likely to avoid the disturbance in the immediate work area. Work on the seawall will be restricted to areas landward of the existing seawall or landward of a temporary sheet pile wall or similar structure during the juvenile salmon spring migration period. The No Build Alternative could result in construction at any time of year to replace a portion of the seawall lost through catastrophic failure.

Construction activities will produce increased human activity for periods of months at locations along the shoreline where activity is frequently moderate to light. Feeding by bald eagles and other birds will potentially be displaced from these limited portions of the shoreline during active construction.

6.1 No Build Alternative

Initial construction would have little effect on marine life for those portions of the seawall where the new seawall is placed shoreward of the exiting seawall (Colman Dock to Myrtle Edwards Park). Removal of the existing seawall would remove those few organisms (scattered barnacles, diatoms, etc.) that are attached to its concrete face and the riprap in contact with the existing seawall. Construction impacts will most likely be the same as identified above, but will occur at an undefined time in the future. Construction impacts might be limited to a portion of the seawall or include the entire length of the seawall, depending on the nature of future failures and decisions to be made in the future. Construction impacts could include removal and replacement of damaged piers if failure of the seawall included damage to one or more of the existing piers such as the Seattle Aquarium. Under Scenario 2 or 3, more in-water work might occur since these scenarios anticipate some type of seawall failure.

Construction in the water between Pier 48 and Colman Dock would consist of pile driving and placement of pile caps and decking over the piles. Pile driving would occur directly in the water producing noise, vibration, and sound pressure within the water column. Hammer-type pile driving can produce sound pressure levels of about 190 dB (re: 1 µPa) within the water column at a distance of about 150 ft in deep water (WSDOT 2003). In shallow water, sound pressure attenuates more quickly than in deep water. Pile driving would occur at depths in the range of 10 to 40 ft. A safe level for fish may be about 150 dB. Sound pressures levels of 180 dB can damage the auditory hair cells of fish. Vibratory driving of piles reduces sound pressure levels 10 to 20 dB.

The potential noise impact from driving piles may be avoided or minimized by using BMPs such as bubble curtains. Bubble curtains surrounding each driven pile could reduce the transmission of energy to the surrounding water, avoiding sound pressure levels that could potentially be injurious to fish. In the low current velocity of shoreline adjacent to the shoreline between Pier 48 and Colman Dock, bubble curtains may be effective in reducing energy transmission below levels that would injure hearing in fish or produce tissue damage in swim bladders.

6.2 Rebuild Alternative

Construction impacts for all alternatives will be the same as described from Colman Dock north to Myrtle Edwards Park. Construction impacts of the same nature will occur between Pier 48 and Colman Dock.

6.3 Aerial Alternative

Construction impacts for all alternatives will be the same as described from Colman Dock north to Myrtle Edwards Park. Construction impacts of the same nature will occur between Pier 48 and Colman Dock.

6.4 Tunnel Alternative

Construction impacts for all alternatives will be the same as described from Colman Dock north to Myrtle Edwards Park. Construction impacts of the same nature will occur between Pier 48 and Colman Dock, but will involve a slightly larger area than with the Rebuild Alternative. Most likely a temporary sheet pile wall will be constructed on the seaward side of the construction area in the shallow subtidal zone at this location between Pier 48 and Colman Dock, where a small portion of Elliott Bay will be filled with the tunnel.

6.5 Bypass Tunnel Alternative

Construction impacts for all alternatives will be the same as described from Colman Dock north to Myrtle Edwards Park. Construction impacts of the same nature will occur between Pier 48 and Colman Dock, but will involve a larger area than with the Rebuild Alternative. Most likely a temporary sheet pile wall will be constructed on the seaward side of the construction area in the shallow subtidal zone at this location.

6.6 Surface Alternative

Construction impacts for all alternatives will be the same as described from Colman Dock north to Myrtle Edwards Park. Construction impacts of the same nature will occur between Pier 48 and Colman Dock.

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Chapter 7 SECONDARY AND CUMULATIVE IMPACTS

Secondary impacts result from the incremental effect of the proposed action when added to other past, present, or future projects. The proposed alternatives for the Alaskan Way Seawall provide a continuation of impacts to the shoreline that occurred with the initial seawall construction and shoreline fill. The previous removal of the natural slope and substrate of the Elliott Bay shoreline greatly modified the habitat and the natural resource functions it provides along the Seattle waterfront. These impacts have not been mitigated, although their degree has been reduced in recent years by removal of some of the piers that covered shallow water habitat along the shoreline.

Proposed reconstruction and expansion of Colman Dock will produce cumulative impacts in the area south of the existing dock. Part of the new over-water cover at this location (18,040 to 32,940 ft^2) is a cumulative impact resulting from the interaction of the proposed reconstruction and expansion of the Colman Dock Ferry Terminal together with the limitations to vehicle access resulting from most of the Alaskan Way Viaduct alternatives. This interaction requires that staging for ferry traffic be relocated to Terminal 46 with a roadway connection to Colman Dock on the west side of Alaskan Way. This impact is described above under Chapter 5, Operational Impacts and Benefits as a direct impact of the Alaskan Way Viaduct project.

Pier 48 may be removed as a part of Colman Dock expansion or Port of Seattle action. Removal of this pier will provide new open water area and an opportunity for intertidal and shallow subtidal habitat construction to restore some lost habitat functions.

Cumulative impacts may result from relatively minor independent impacts of multiple projects that become collectively significant over time if not properly mitigated. The removal of Pier 48 could either be a cumulative or a secondary impact, depending on the purpose and timing of its removal.

Benefits of seawall replacement for each alternative, other than No Build, include greatly reduced risk of catastrophic failure and its inherent damage to the shallow water habitat of the Elliott Bay shoreline. The volume of Elliott Bay will increase with each Build Alternative other than the Bypass Tunnel (see Exhibit 5-1). This increase will produce slightly more habitat along Elliott Bay's Seattle waterfront. Projects to restore previously lost habitat functions may or may not be included in the project where practical (see Attachment D).

7.1 No Build Alternative

No cumulative or secondary impacts can be identified because this alternative does not propose any specific action and any identified time.

7.2 Rebuild Alternative

Cumulative and secondary impacts will be as described above.

7.3 Aerial Alternative

Cumulative and secondary impacts will be as described above.

7.4 Tunnel Alternative

Cumulative and secondary impacts will be as described above.

7.5 Bypass Tunnel Alternative

Cumulative and secondary impacts will be as described above.

7.6 Surface Alternative

Cumulative and secondary impacts will be as described above.

Chapter 8 Operational Mitigation

Operation of the replaced seawall will not require new actions that will affect Seattle's shoreline habitat of Elliott Bay. The rebuilt seawall will increase, rather than decrease, the water area of Elliott Bay for the foreseeable future. The risk of catastrophic failure of the seawall and resulting environmental damage to the shallow water habitat will be greatly reduced with the rebuilt seawall. These benefits provided by replacing the seawall will continue throughout the life of the project. Actions necessary to maintain the existing seawall will be greatly reduced by restoration of the structural support with the new seawall. In-water work will result in a short-term loss of the primary production of macroalgae that are a part of the basis of the food web supporting estuarine fishes, including migrating juvenile salmon.

Moving the location of the seawall seaward in the area between Pier 48 and Colman Dock with the tunnel alternatives will require mitigation. Habitat functions lost in the area of the new fill will be replaced at another location along the Elliott Bay shoreline through construction of new habitat or beneficial modification of existing habitat.

Restoration of habitat functions that are compatible with the current uses of the Seattle shoreline are being considered as mitigation of the proposed replacement of the seawall impacts together with continuation of unmitigated impacts resulting from the original seawall. Mitigation will be provided for identified impacts at appropriate locations along the Elliott Bay shoreline. There are a variety of potential actions to restore habitat functions along Seattle's Elliott Bay shoreline. Specific actions will be developed in cooperation with resource agency representatives as the project design develops and the permitting process proceeds. Specific actions have not yet been proposed or discussed with resource agency representatives. A draft memorandum identifying opportunities to restore intertidal and shallow water habitat functions at a number of locations has been prepared (Attachment D). Actions that will be taken to mitigate the cumulative impacts of the existing seawall and the rebuilt seawall have yet to be determined.

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Chapter 9 CONSTRUCTION MITIGATION

The construction approach is to conduct all practical construction activities on the upland portions of the project isolated from the aquatic environment of Elliott Bay to avoid impacts to the aquatic habitat. These areas are currently highly developed and devoted to intensive human use. In-water and over-water construction will be conducted only in the area between Pier 48 and Colman Dock where new structures are required on the Elliott Bay side of the existing seawall. Removal of the existing seawall will also require in-water work, as will removal of the existing sheet pile wall enclosing the fill at Pier 48 will require in-water work.

Incorporating conservation measures into the proposed action is a process of avoiding, minimizing, rectifying, or compensating for impacts to species and critical habitat. The City of Seattle and WSDOT will design the proposed action to incorporate BMPs and conservation measures during construction as listed below.

In-water construction along the Elliott Bay shoreline is likely to be prohibited from March 15 to July 15 during each year of construction to protect migrating juvenile salmonids (Chinook, chum, coho, steelhead, bull trout). Most construction will occur on the landside of the existing seawall, avoiding in-water construction. Shoreline construction in the Pier 48 to Colman Dock area may be isolated from Elliott Bay by sheet pile walls to avoid in-water work during the prohibited period. The area isolated by the sheet pile will be filled by the new tunnel and seawall. Removal of the existing seawall and riprap will not occur during the prohibition period unless special provisions are made to isolate the work site.

Debris from work on the seawall will be contained and prevented from entering Elliott Bay by implementing BMPs. BMPs will include placing an appropriate silt curtain and or debris boom around the work area, and containing liquid runoff within the curbs of the upland area. Liquid runoff will be treated prior to discharge. Spoils from deep soil mixing and jet grouting will be stockpiled on site for several days for dewatering and treatment of water as required (see Appendix S, Water Resources Discipline Report). Potentially contaminated spoils will be tested and disposed of at appropriate upland facilities.

No wet or curing concrete, including washout of equipment, will be permitted to enter Elliott Bay. Runoff from activities involving wet or curing concrete activities will be collected and treated prior to discharge to Elliott Bay.

Containment structures will be installed along the roadway curbs during upland construction to contain debris on the roadway.

Erosion will be controlled in disturbed areas by implementing the following BMPS:

- Silt dams and catchments will be installed along the upland side of the site.
- Construction will occur landward of the existing seawall along most of the project area.
- In-water construction between Pier 48 and Colman Dock will occur within containment structures such as temporary sheet pile walls and silt curtains.

Refueling activities will be conducted within designated refueling areas. Spill control measures will be developed and implemented as appropriate. Emergency response plans will be developed for fueling and concrete preparation activity areas.

Work areas will be primarily upland, minimizing light and noise impacts over and within Elliott Bay.

Chapter 10 PERMITS AND APPROVALS

10.1 Federal Regulations

The selected alternative, other than No Build, will require a National Pollution Discharge Elimination System (NPDES) State Waste Discharge Individual Permit for Process Water and Storm Water under the Clean Water Act Section 402. An NPDES Permit is required for any discharge of pollutants into the waters of the United States to protect aquatic habitat and human uses.

The Magnuson-Stevens Act requires proposed projects with a federal nexus to evaluate potential impacts to habitat of commercially managed fish populations. The Seattle shoreline provides habitat potentially supporting a number of commercially managed species. Essential fish habitat (EFH) has been defined for the purposes of the Magnuson-Stevens Act as "*those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity*" (NMFS 1999b). Feeding and growth activities have been identified for some commercially managed species along the Seattle shoreline.

Section 7 of the Endangered Species Act (ESA) requires federal agencies to ensure that their actions do not jeopardize listed species or their habitats. Federal funding for the project provides a nexus to the ESA. In this regard, federal actions include permitting and providing funding for projects. ESA review of a project begins with project representatives requesting a list of endangered or threatened species from USFWS and review of the NOAA Fisheries web page list (http://www.nwr.noaa.gov/esalist.htm). If a listed species is known to occur in the project vicinity, the lead agency or its designee must complete a Biological Assessment or Evaluation (BA or BE) describing how the project will affect the species or their critical habitat. If the evaluation determines that a listed species is likely to be harmed by the project, the lead agency must enter formal consultation with the USFWS and/or NOAA Fisheries to ensure that its actions will conserve the species and its critical habitat. The presence of and potential impacts to Chinook salmon, bull trout, and bald eagles in the project area will be addressed through a BA.

The potential taking of marine mammals is regulated under Section 101(a)(5)(A) and (D) of the Marine Mammal Protection Act (16 U.S.C 1361). This act directs the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals for specified activities within a specified geographical region if certain findings are made and either regulations are issued or, if the taking is limited to harassment, notice of a proposed authorization is provided to the public for review. Permission may be granted if NOAA Fisheries finds that the taking will have no more than a negligible impact on the species or stock(s) and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses and if the permissible methods of taking and requirements pertaining to the monitoring and reporting of such taking are set forth.

Under the Bald Eagle Protection Act of 1940 (16 U.S.C. 668-668d, 54 Stat. 250) as amended P.L. 92-535 (86 Stat. 1064) October 23, 1972; and P.L. 95-616 (92 Stat. 3114) November 8, 1978, bald eagles that may be in the project area are protected. The bald eagle and the golden eagle are protected by prohibiting the taking, possession, and commerce of these birds, except under certain specified conditions. The 1972 amendments provide for rewards for information leading to arrest and conviction for violation of the Act. The 1978 amendment authorizes the Secretary of the Interior to permit the taking of golden eagle nests that interfere with resource development or recovery operations.

10.2 State Regulations

The Washington Administrative Code (WAC) provides regulations that will apply to each of the alternatives considered for replacement of the Alaskan Way Seawall and the Alaskan Way Viaduct. Ecology regulates discharges to surface waters of the state under several WAC chapters.

A Hydraulic Project Approval (HPA) will be required for construction of the seawall. The approval issued by the WDFW will include provisions for construction and possibly operation of the seawall. Habitat mitigation and restoration actions may be conditions of the HPA.

Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201A) provides water quality standards for ambient water quality. This regulation requires a Section 401 Water Quality Certification, which certifies compliance with state water quality standards. The certification process evaluates the effects of the proposed project and its effect on water quality. Activities producing a discharge to navigable waters must comply with the applicable provisions of Sections 301, 302, 306, and 307 of the Clean Water Act. See Appendix S, Water Resources Discipline Report for discussion of this regulation and its application to the project.

Sediment Management Standards, WAC 173-204, provides the standards for sediment quality in Puget Sound. The alternatives will involve disruption of sediment with removal and replacement of riprap as well as removal of the existing seawall. Activities removing existing bottom materials within the intertidal and shallow subtidal areas of the Seattle shoreline will be regulated under these standards.

10.3 City Regulations

The City of Seattle Shoreline Substantial Development Permit process will apply to each of the alternatives. Under the City of Seattle's Municipal Code (SMC 23.60), a Shoreline Substantial Development Permit is required for any development or construction activity valued at $5,000 or more that is located within 200 feet of the waters of the state. Special uses, conditional use permits, and/or variances are integrated into the shoreline permit process. If a shoreline variance or conditional use permit is required, Ecology must also approve or deny the permit, or approve the permit with conditions.

10.4 ESA Species Information

The Endangered Species Act (ESA) requires information on listed species and potential takes be identified and provided in a Biological Assessment for use by the Services (USFWS, NOAA Fisheries) in preparation of Biological Opinions for the proposed project. Evaluation of listed species under the ESA requires information on the biology, habitat, and distribution of the species within the project vicinity. The following provides information on ESA listed species likely to be present in Elliott Bay along the Seattle Waterfront.

10.4.1 Chinook Salmon Effects Analysis

Puget Sound Chinook salmon are listed as threatened under the ESA (Myers et al. 1998; NMFS 1998a). Thus, it is necessary to submit a biological evaluation/assessment to NOAA Fisheries for their consideration and preparation of a Biological Opinion supporting federal permits and approvals for construction of the selected alternative. Young Chinook salmon commonly rear along shorelines in shallow water (Healey 1991), where they feed on pelagic and epibenthic prey (Meyer et al. 1980; Weitkamp and Campbell 1980) and are potentially affected by shoreline projects (NMFS 1998a).

Direct and Indirect Effects

Potential direct and indirect effects of seawall reconstruction could occur by exposure of adult or juvenile Chinook salmon to temporarily degraded water quality associated with the construction. However, no in-water work will be permitted during the fish closure period of March 15 to July 15. During this period, all work will be on the landside of the existing seawall or behind some other structure such as temporary sheet pile. No physical degradation of the existing shoreline habitat will occur with most alternatives. Several alternatives will move the existing seawall into Elliott Bay along the 420 feet of shoreline between Pier 48 and Colman Dock. The new shoreline will again be a vertical seawall with riprap at its base, but with the riprap subtidal rather than intertidal as with the existing seawall.

The installation of new seawall segments together with excavation of the existing seawall and subsequent fill has the potential for direct and indirect effects on Chinook salmon and their habitat if BMPs (i.e., erosion control) are not followed and fine sediment enters the Elliott Bay shoreline. Fine sediment and turbidity have the potential to affect the behavior or feeding success of juvenile Chinook salmon, should any be present during the work period. During the construction period, it is likely that there will be few or no juvenile Chinook salmon migrating along the Seattle waterfront.

Suspended solids reduce light transmission and, if chronic, can suppress primary production as well as feeding by young salmon. However, generally sediment levels producing turbidity greater than 150 nephelometric turbidity units (NTUs) are necessary to produce a clear effect. These conditions are not likely to affect migrating adult Chinook salmon. Adult fall Chinook salmon and other salmon are not likely to be present in close proximity to the Seattle waterfront. Adult salmon commonly migrate into highly turbid conditions such as the Puyallup River and other streams under freshet conditions when suspended sediment and turbidity levels are high. No spawning or feeding activity is likely to occur along the Seattle waterfront (Williams et al. 1975; WDF et al. 1993).

Because the project will meet U.S. Environmental Protection Agency/Ecology standards for water quality, the survival of adult and juvenile fish should not be reduced. No additional impervious surface will be added to the project site. Implementing the conservation measures described in Chapter 9 during construction will reduce the potential for degrading water quality. Even if these measures fail for short periods, the effects of a sediment plume are likely to be short-lived and should not produce toxic conditions or result in a “take” under the ESA.

Noise, vibration, and light from the operation of machinery and the activities of construction personnel are not likely to have significant direct or indirect effects to Chinook salmon. Construction and removal activities will meet state standards for noise control and comply with the City of Seattle Noise Ordinance. Also, noise generated by vehicular and shipping traffic, commercial operations, and local businesses already exists in the area. Artificial lighting effects are not likely to be different than the existing light conditions along the waterfront.

Other direct and indirect effects could result from debris or dust falling into Elliott Bay from work on the seawall and associated structures, columns, sidewalks, support walls, or moveable span. The effects from these activities to water quality will be the same as mentioned above and will be minimized by following the conservation measures described in Chapter 9.

Cumulative Effects

The rebuilding and potential expansion of the Washington State Ferry terminal at Colman Dock will potentially add cumulative impacts of in-water structures and over-water shading in the area between Pier 48 and Colman Dock as described in Chapter 7, Secondary and Cumulative Impacts. Mitigation for the Colman Dock expansion may be combined with mitigation or habitat restoration for the Alaskan Way Viaduct and Seawall Replacement Project. Sediment cleanup actions may occur along the seawall in the future, but no known actions are now planned. No other state or private action is expected to occur in the vicinity of the project site in the foreseeable future that will measurably add to any unmitigated effects of the project. Other waterfront projects identified will improve and not degrade shoreline habitat conditions.

Interrelated and Interdependent Actions

No interrelated and interdependent actions that will affect Chinook salmon are expected to result from the project. The project is linked to the reconstruction of the Alaskan Way Viaduct but is not linked, directly or indirectly, to any other projects in the area.

Determination

The *Checklist for Documenting Environmental Baseline and Effects of Proposed Actions(s) on Relevant Indicators* is included in Attachment C and was used to guide the determination of effect for the proposed action on Chinook salmon. An extensive field survey of the habitat parameters identified in the checklist was performed in the action area. The checklist was completed using the best available scientific information for the area, together with the project-specific survey information.

In summary, there are only a few spawning or migrating juvenile Chinook salmon expected to be present near the project site during the work period. The seawall reconstruction does involve in-water work, but is not expected to degrade shoreline habitat. BMPs will be implemented to reduce the risk of runoff.

Therefore, we conclude that the seawall reconstruction **may affect, but is not likely to adversely affect** Chinook salmon, and will **not result in the destruction or adverse modification of critical habitat** for Chinook salmon in the action area.

10.4.2 Essential Fish Habitat Effects Analysis

This evaluation of the potential effects of the Alaskan Way Seawall replacement project on EFH is made pursuant to Section 305(b)(2) of the Magnuson-Stevens Act. This act requires federal agencies to consult with

NOAA Fisheries regarding their actions or proposed actions (authorized, funded, or undertaken) that may "adversely affect" EFH. "Adverse effect" means any impact that reduces the quality and/or quantity of EFH, including direct (e.g., contamination or physical disruption), indirect (e.g., loss of prey, reduction in species' fecundity), site-specific, and habitat-wide impacts. It also includes individual, cumulative, and synergistic consequences of actions.

Cumulative impacts are incremental impacts occurring within a watershed or marine ecosystem context that may result from individually minor but collectively significant actions. The assessment of cumulative impacts is a generic evaluation of actions occurring within the watershed or marine ecosystem that potentially have adverse effects on the ecological structure or function of EFH. The assessment should specifically consider the habitat variables that control or limit a managed species' use of a habitat. It should also consider the effects of all impacts that affect either the quantity or quality of EFH. For any federal action that may adversely affect EFH (except those activities covered by a General Concurrence), federal agencies must provide NOAA Fisheries with a written assessment of the effects of that action on EFH. Federal agencies may incorporate an EFH assessment into documents prepared for other purposes, such as ESA Section 7 BAs or BEs.

Direct, Indirect, and Cumulative Effects

Potential impacts of the Alaskan Way Seawall reconstruction to ESA listed fish species are discussed in Sections 6.1.1 and 6.1.3 of the BA. Strict adherence to BMPs will protect the Elliott Bay habitat from water quality effects during project construction. These guidelines should prevent any significant adverse impact to EFH for Chinook salmon in the Elliott Bay and the Duwamish River. There should be no direct, indirect, or cumulative adverse effects upon Pacific Coast salmon EFH during project construction.

Determination

Based on the essential fish habitat requirements of Pacific Coast salmon species, the potential direct, indirect, and cumulative effects of the construction of the proposed project are **not likely to adversely affect** any identified EFH for the project site or action area evaluated.

10.4.3 Bull Trout Effects Analysis

Bull trout in Puget Sound are listed as threatened under the ESA (USFWS 1998a,b). Thus, it is necessary to submit a BE/BA to the USFWS for their consideration and preparation of a Biological Opinion supporting federal permits and approvals for construction of the selected alternative.

Direct and Indirect Effects

Little information exists on the current status and distribution of bull trout in the Green River basin. For this analysis, we examined the potential life history strategies of bull trout that might exist in the project vicinity, including resident and migratory forms (Brown 1992; Mongillo 1993; Rieman and McIntyre 1993; Goetz 1994; Kramer 1994; WDFW 1998). We assume that small numbers of anadromous bull trout from other rivers will be present during the late spring and summer in the Elliott Bay vicinity since they have been observed in the lower Duwamish River and in the Pier 90/91 vicinity of Elliott Bay. The conservative assumption that bull trout are present in the project area is based on their capacity to migrate throughout Puget Sound shoreline areas from distant watersheds, and the records of a few individuals in the project vicinity.

Resident forms of bull trout spend their entire lives in tributary reaches of rivers and will not be present in Elliott Bay. Most of the Duwamish River mainstem is lacking the habitat complexity and cold water temperatures required by bull trout. Spawning habitat for bull trout is absent within the action area. Access to the potential spawning and rearing habitat of the upper Green River and its tributaries is isolated from the mainstem river by the City of Tacoma diversion dam and Howard Hanson Dam. Thus, only anadromous bull trout from other river basins are likely to be present in Elliott Bay.

Any direct and indirect effects on bull trout that may result from seawall reconstruction are similar to those described above (see Section 10.4.1) for Chinook salmon. Effects of construction on the Elliott Bay shoreline will meet water quality standards imposed by the state and federal laws (e.g., Clean Water Act Section 404/401, HPA permits). Implementing the conservation measures as described in Chapter 9 during construction will reduce the potential for degrading water quality.

Cumulative Effects

The rebuilding and potential expansion of the Washington State Ferry terminal at Colman Dock will potentially add cumulative impacts of in-water structures and over-water shading in the area between Pier 48 and Colman Dock as described in Chapter 7, Secondary and Cumulative Impacts. No state or private action is expected to occur in the vicinity of the project site in the foreseeable future that will measurably add to any unmitigated effects of the project.

Interrelated and Interdependent Actions

No interrelated and interdependent actions that will affect bull trout are expected with the project. The Alaskan Way Viaduct and Seawall

Replacement Project is not linked, directly or indirectly, to any other projects in the area.

Determination

The *Checklist for Documenting Environmental Baseline and Effects of Proposed Actions(s) on Relevant Indicators* for bull trout is included in Attachment C and is used to guide the determination of effect for the proposed seawall on bull trout. An extensive field survey of the habitat parameters was performed in the area of the action. The checklist was also completed using the best available scientific information for the area.

Only extremely low numbers of bull trout have been observed in the lower Green River and the Duwamish River (USFWS 1999a). These are likely foraging adults from adjacent systems since there is no bull trout spawning habitat below Howard Hanson Dam. Thus, there is a low probability of bull trout presence in the work area. Based on the probable lack of bull trout in the work area, the absence of spawning habitat, and the use of BMPs, we conclude that the proposed project **may affect, but is not likely to adversely affect** bull trout or their habitat in the action area.

10.4.4 Bald Eagle Effects Analysis

The bald eagle was previously listed as threatened under the ESA in 1978. Although still listed as threatened, with recovery of the species the USFWS proposed that the bald eagle be delisted (USFWS 1999b). They are covered in this evaluation because they are still officially listed and there is general concern for bald eagles. It is appropriate to submit a BE/BA to USFWS for their consideration and preparation of a Biological Opinion, if necessary, supporting federal permits and approvals for construction of the selected alternative.

Direct Effects

The proposed project will have no direct effects on nesting or wintering bald eagles or their prey base. Priority Habitats and Species (PHS) data indicate the nearest bald eagle nest is present within the greenbelt on the west side of the Duwamish River slightly more than 0.5 mile from the southern end of the project area. The PHS data do not indicate any winter concentration areas, roost sites, or nest sites occurring within the project area.

Vehicular and shipping traffic, industrial operations, local businesses, and residents generate existing noise and human disturbance in the area. Local bald eagles are likely habituated to human activities in the project vicinity. As such, short-term noise and human disturbance associated with construction activities is not likely to affect bald eagle behavior. Any disturbance to foraging behavior is expected to be minor and temporary. No nesting or roost trees will be affected, and the construction should not significantly affect the eagles' aquatic prey base. Because of these factors, no alteration or long-term degradation of wintering habitat will occur, and the survival and reproductive success of eagles will be unaffected.

Indirect Effects

Possible indirect effects to bald eagles will include disturbance and other adverse impacts to prey species, primarily waterfowl and fish. Disturbance of prey during construction is unlikely due to the reasons discussed in Chapter 6, and because there are no features such as pools or side channels in or near the project site where prey are likely to congregate. This fact, combined with the lack of suitable perches, makes it unlikely that bald eagles spend much time foraging in the project vicinity. During any pile driving activities that may occur during construction along the waterfront, eagles may avoid the area due to noise disturbance.

With regard to water quality, with implementation of the conservation measures described in Chapter 9, the potential for degrading water quality will be reduced.

Cumulative Effects

No other state or private action is expected to occur in the vicinity of the project site in the foreseeable future that will measurably add to any unmitigated effects of the project.

Interrelated and Interdependent Actions

No interrelated and interdependent actions that will affect bald eagles are expected with the project. The project is not linked, directly or indirectly, to any other projects in the area.

Determination

Due to the lack of suitable foraging habitat and brief nature of the construction activities during the very end of the wintering period, bald eagles will not be affected. As mentioned above, there are no wintering concentrations of eagles in the project area, nor are there nest or roost trees within 0.5 mile of the project. Therefore, we conclude that the project will have **no effect** on bald eagles.

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ATTACHMENT A

Life History Information for ESA Fish Species

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A. LIFE HISTORY INFORMATION FOR ESA FISH SPECIES

The shoreline of Elliott Bay along the Alaskan Way Seawall is inhabited by a wide variety of marine invertebrate and fish species, including anadromous salmonids. These species include several listed under the Endangered Species Act (Puget Sound Chinook salmon, Puget Sound bull trout).

A.1 CHINOOK SALMON

Chinook salmon produced in the Green-Duwamish River migrate through Elliott Bay as juveniles on their journey to the ocean and as adults during their spawning migration.

A.1.1 Pertinent Life History

Although summer/fall Chinook salmon commonly migrate into Washington's rivers in August and September (Wydoski and Whitney 1979), the Green River stock tends to return earlier. Green River fall Chinook begin entering the river as early as mid-June, peak in August and continue entering the river through early November (Weitkamp and Ruggerone 2000). Spawning begins in mid-September, peaks in October, and continues into November, similar to other Chinook salmon stocks in south Puget Sound. Adult Chinook salmon have been recorded in the Green River as early as late May (Williams et al. 1975). These probably constitute the small population of spring or summer Chinook salmon that use the upper reaches of the river system. Naturally spawning Chinook salmon are most abundant in the mainstem of the Green River from the City of Tacoma water diversion downstream to Soos Creek, as well as in Soos Creek and Newaukum Creeks (WDF et al. 1993; Williams et al. 1975; Weitkamp and Ruggerone 2000).

Chinook fry emerge from gravel during late winter and spring. Following emergence, the "ocean type" juvenile fall Chinook rear in fresh water from a few days to about 3 months, migrating to the estuary and offshore during their first year of life (Myers et al. 1998; Weitkamp and Ruggerone 2000). The timing of the juvenile migration in the Green River system potentially produces substantial numbers of young Chinook in the project area from March through June. Yearling spring Chinook smolts are also likely to migrate past the project site during this period, corresponding with the normally high spring run-off flows. Peak abundance of juvenile Chinook in the Duwamish River estuary occurs during late May and early June, although Chinook may be present through July (Bostick 1955; Salo 1969; Weitkamp and Campbell 1980; Meyer et al. 1980).

A.1.2 Juvenile Salmon Habitat

Juvenile Chinook salmon rear in the entire accessible length of the Green River and in those tributaries used by spawning adults. Much early rearing also takes place in the basin's estuarine waters with the lower Duwamish River and Elliott Bay providing critical rearing and migration habitat. The estuarine area of the lower Duwamish River and Elliott Bay provides a rearing area where young Chinook grow rapidly to reach a size suitable for offshore migration. Residence time in the estuary is relatively brief. Weitkamp and Schadt (1982) concluded from a mark-recapture study that residence time of chum in the Duwamish estuary was approximately one week. Warner and Fritz (1995) noted that most Chinook smolts left the system within two weeks of peak abundance in the estuary. Food for the juveniles appears to be relatively abundant in the Green-Duwamish River. Warner and Fritz (1995) reported that CWT Chinook released from the hatchery and recaptured in the estuary after approximately 25 days (range: 8 to 61 days) had gained approximately 1 gram or 70% gain in weight (range: 3.7 gram or 540% gain).

Juveniles rapidly reach a size of 70mm or greater appropriate for offshore migration. Salo (1969) reported that mean length of Chinook salmon captured in the estuary increased from 76 mm on June 1 to over 90 mm by early July. Weitkamp and Schadt (1982) found young Chinook in the lower Duwamish ranged from 55 to 90 mm. Most of the juvenile Chinook were in the 70 to 85 mm size range.

Young Chinook fry tend to rear and migrate in shallow water along the banks and avoid the high velocity water (thalweg) near the center of the channel (Healey 1991). Juveniles are seldom found in estuarine waters at depths greater than about 6 ft, although they do migrate in the surface water away from shore at times. Migration commonly occurs during the night, although some fish may migrate during the day (Healey 1991).

A.1.3 Adult Salmon Habitat

Although commercial and sports fishers have historically studied the distribution of adult salmon as they approach home streams, there is not a great deal of recorded scientific information. Stauffer (1970) found adult Chinook tagged near the mouth of the Green/Duwamish R. appeared to mill within the lower estuary for some time prior to migrating upstream. It appears to be common for adult salmon to slow or halt their migration for a period of time as they near or enter estuaries (Barker 1979) until they are stimulated to move upstream by increasing river flow (Banks 1969). Generally, adult salmon appear to migrate at a moderate rate of 6 to 40 km/day (4 to 25 mi/day) as they approach and move into estuaries (Madison et al. 1972; Stasko et al. 1976; Ichihara and Nakamura 1982; Anderson and Beacham 1983; Groot et al. 1987; Manzer, Morley, and Girodat 1985; Quinn 1988a; Ruggerone et al. 1990). During this nearshore migration, the adult salmon commonly remain relatively near the surface. Johnson (1960) found adult Chinook generally stayed within at depths of less than 9 m (30 ft) when near shore and less than 12 m (40 ft) when in open water. Quinn (1988a) reported tagged Chinook spent most of their time in relatively warm brackish water near the surface rather than in cooler, more saline water of the deeper estuary, generally at depths of less than 4 m (13 ft). Gray and Haynes (1977) observed that after entering the Columbia River, spring Chinook generally remained deeper than 2 m (7 ft) at mean depths of 5 to 6 m (16 to 20 ft).

Other salmon have somewhat different depth distributions as they approach estuaries. In cool, oceanic water tagged sockeye were found to remain about 3 to 4 m from the surface, while spending some time as deep as 30 to 40 m (98 to 131 ft) (Quinn 1988a). In the stratified water of the river plume, the sockeye tended to remain at depths of about 10 to 20 m (33 to 66 ft). Steelhead migrate very close to the water surface with a geometric mean depth of 1.6 m (5 ft) (Ruggerone 1990). He reported tagged steelhead spent an average of 72% of the time within 1 m (3 ft) of the surface. Ichihara and Nakamura (1982) determined chum salmon were within 5 m (16 ft) of the water surface 44 % of the time, but did also migrate at greater depths resulting in an average depth of 13.7 m (45 ft).

Adult salmon do not appear to commonly follow shorelines as the approach and migrate through estuaries. Stasko, Horrall, and Hasler (1976) concluded sockeye approaching the Fraser River a relatively straight path toward the river along the axis of the tidal currents and did not follow shorelines. Quinn and terHart (1987) found sockeye encountering obstacles such as islands swam back to open water and resumed their original orientation rather than following shorelines. Chinook in the Columbia River swam actively into the current with periods of milling during slack water (Quinn 1988b; Olsen 1989). Generally, these Chinook were in open water and did not follow the shorelines. Following entry into an estuary adults commonly appear to remain within a small area for some time. Barker (1979) determined that Chinook, chum, coho, and pink salmon tagged in Puget Sound were recovered over periods of 4 days to 2 months later in Puget Sound, indicating that many were not actively moving upstream into rivers. Stauffer (1970) found that Chinook tagged near the mouth of the Green/Duwamish River appeared to mill within the lower portion of the estuary.

The information contained in these scientific reports indicates that most adult salmon are not likely to migrate along the Seattle waterfront, and they are not likely to hold along this shoreline. However, individual adults may at times be found in the immediate vicinity of the waterfront.

A.1.4 Stock Status

The ESA status review of Chinook salmon populations from Washington, Oregon, Idaho, and California conducted by NMFS defined 15 evolutionarily significant units (ESUs) (each considered a species under the ESA). Naturally spawned spring, summer/fall, and fall Chinook salmon runs from the Puget Sound ESU were considered likely to become endangered in the foreseeable future (Myers et al. 1998). The abundance of Chinook salmon in the Puget Sound ESU has declined substantially from historic levels, and there is concern over the effects of hatchery supplementation on genetic fitness of stocks, as well as severely degraded spawning and rearing habitats throughout the area (Myers et al. 1998). In addition, harvest exploitation rates in excess of 90% were estimated to occur on some Puget Sound Chinook salmon stocks. I n May 1999 NMFS issued a ruling listing the Puget Sound ESU as threatened (NMFS 1999a). Primary factors contributing to declines in Chinook salmon in the Puget Sound ESU include habitat blockages, hatchery introgression, urbanization, logging, hydropower development, harvests, and flood control and flood effects (NMFS 1998).

The Green River fall Chinook salmon stock is healthy based on escapement levels (Weitkamp and Ruggerone 2000). Escapement levels, based upon redd counts, averaged 7,600 from 1987 to 1991 with a range of 4,792 to 10,263 fish (WDF et al. 1993).

Presently, Chinook salmon in the Green River are nearly all summer/fall run fish. Chinook begin entering the Duwamish River in mid-June, peak in August and continue entering the river through early November (Weitkamp and Ruggerone 2000). Although spring Chinook salmon are occasionally found in the Green River, it does not appear that these fish constitute a self-sustained run. The Duwamish/Green River fall Chinook salmon stock is part of the Puget Sound ESU (NMFS 1999a). Duwamish/Green River basin summer/fall Chinook salmon are classified as a distinct stock based on geographic distribution. Stock origin is mixed, with hatchery production at Soos Creek and natural spawning throughout the river. No genetic data exists for natural spawners. Hatchery Chinook salmon have been documented in the natural spawning populations in the Green River and Newaukum Creek. Coded-wire-tag data indicated that the percentage of hatchery fish on the mainstem and Newaukum Creek spawning grounds typically exceeds 25% and may be considerably higher in some years (Weitkamp and Ruggerone 2000). Genetic data (allele frequencies) are available for Chinook sampled in Newaukum Creek (one year of data), a tributary to the Green River, and for

Chinook collected in the Green River Hatchery on Soos Creek (Weitkamp and Ruggerone 2000). Genetic analysis indicated that the hatchery and naturally spawning stocks were sufficiently similar that they could not be distinguished using genetic stock identification techniques.

Chinook salmon spawning in the mainstem Green River occurs over about 40 miles of river, from the City of Tacoma diversion downstream to the vicinity of RM 11.0, which is roughly 7 miles upstream of the project site (WDF et al. 1993). The Chinook salmon populating the Green River system are principally fall Chinook salmon, as distinguished from the spring Chinook salmon race (Williams et el. 1975). Spring Chinook salmon do utilize the system to some degree, although their numbers are thought to be limited and their spawning grounds located in the upper Green River Gorge (Williams et el. 1975). The Duwamish River summer/fall Chinook salmon stock is similar to other Puget Sound stocks in the timing of its spawning activities, which occur in mid-September through October (WDF et al. 1993).

A.2 BULL TROUT

The USFWS (1998a) identified five distinct population segments (DPSs) of bull trout in the coterminous U.S. The Coastal-Puget Sound bull trout DPS includes 34 sub-populations (USFWS 1998b, 1999a). The USFWS listed bull trout in the Coastal-Puget Sound DPS as threatened under ESA on November 1, 1999 (USFWS 1999a).

Four life history forms are recognized for bull trout, which include resident (non-migratory), adfluvial (lake dwelling), fluvial (migratory stream and river dwelling), and anadromous fish (saltwater migratory). Only the anadromous life history form is pertinent to the Seawall replacement project. The Coastal-Puget Sound population segment of bull trout is unique because it is thought to contain the only anadromous forms of bull trout within the coterminous U.S. (USFWS 1998a). The status of the migratory (fluvial, adfluvial, and anadromous) forms are of greatest concern throughout most of their range. The majority of the remaining anadromous populations in some areas may be largely composed of resident bull trout (Leary et al. 1991; Williams and Mullan 1992).

Bull trout have a wide but very patchy distribution across their range, even in pristine environments (Rieman and McIntyre 1993). Bull trout have been extirpated from many of the large rivers within their historic range and exist primarily in isolated headwater populations. The decline of bull trout has been attributed to habitat degradation, blockage of migratory corridors by dams, poor water quality, the introduction of non-native species, and the effects of past fisheries management practices (USFWS 1998a).

Historically, bull trout were probably well distributed throughout the central Puget Sound region (Goetz 1994). Currently both bull trout and Dolly Varden are collectively classified as “native char” since their morphological characteristics make them virtually indistinguishable in the field. In fact, WDFW has combined information on their status and distribution into a common inventory (WDFW 1998). Although the Green River is known to support native char, information regarding the presence, abundance, distribution, and life history of bull trout in the basin is extremely limited or unavailable (WDFW 1998). Only a few native char have been observed in the lower reaches of the Green River drainage, indicating the number of native char that presently use this river is small. During the 1930s, Pautzke and Meigs (1940) described the Green River as containing a “few” Dolly Varden. A single native char was reported in Soos Creek in 1956 (King County DNR 2000). A single native char was also observed at the mouth of the Duwamish River in the spring of 1984 (Warner, personal communication). Native char have been captured in the Green River as far upstream as RM 40.0 (Watson and Toth 1994). Fish distribution and habitat surveys by the United States Forest Service (USFS) (1996) and extensive presence/absence surveys by Plum Creek Timber (Watson and Toth 1994) have found no native char above Howard Hansen Reservoir. Mongillo (1993) classified the bull trout population in the Green River as a remnant population with unknown status. It is not known whether the Green River habitat can currently support native char, or if there was any historical use of the upper watershed (WDFW 1998). The stock status and life history forms of the Green/Duwamish River sub-population are unknown (WDFW 1998; USFWS 1998b) with USFWS estimating total abundance for the sub-population at less than 5,000 individuals or 500 adults.

Anadromous bull trout are known to migrate extensively, and enter rivers other than their natal system to feed or spawn (Armstrong 1984). These migrant fish are less likely to reach upstream tributaries. The native char that have been recently observed in the lower Green River may be anadromous forms, which have migrated into this drainage from other rivers (WDFW 1998). Self sustaining populations of native char occur in the upper Cedar River drainage (including Cedar and Rex Rivers and Chester Morse Lake), the White River drainage, and the Skykomish River (upper Snohomish River drainage) (WDFW 1998). Incidental and anecdotal observations indicate bull trout in Issaquah Creek, lower and middle Cedar River, and lower Green River. These observations likely include a mixture of fluvial and anadromous bull trout.

A.2.1 Pertinent Life History

The anadromous life-history form of bull trout is not well understood (see USFWS 1999a). For many years, it was thought that anadromous char in Washington were Dolly Varden and that freshwater char were bull trout. There is conclusive evidence that anadromous bull trout populate Puget Sound (Kraemer 1994), and anecdotal evidence suggests these native char were once much more abundant (USFWS 1999a). In Washington State, bull trout and Dolly Varden coexist and are managed as a single species, native char. Separate inventories are not maintained by WDFW due to the considerable biological similarities in life history and habitat requirements that exist between the two species. Although historic reports of char may have specified either bull trout or Dolly Varden, methodologies for reliably distinguishing between the two have only recently been developed and have not yet been widely applied (WDFW 1998).

Bull trout are considered to be optionally anadromous, (i.e., the survival of individuals is not dependent upon whether they can migrate to sea), in contrast to obligate anadromous species like pink (*Oncorhynchus gorbuscha*) and chum salmon (Pauley 1991). Nonetheless, the anadromous life history form is important to the long-term persistence of bull trout and their metapopulation structure. Anadromous char are generally larger and more fecund than their freshwater counterparts and migratory forms play an important role in facilitating gene flow among sub-populations.

Bull trout are believed to be restricted in their spawning distribution by water temperature. Bull trout spawn in late summer and early fall (Bjornn 1991). Locally, anadromous forms typically return to fresh water in late summer and fall to spawn in upper tributaries and headwater areas. In the Green River system, spawning information is lacking. Puget Sound stocks typically initiate spawning in late October or early November as water temperature falls below 7 to 8°C. Spawning habitat almost invariably consists of very clean gravel, often in areas of groundwater upwelling or cold spring inflow (Goetz 1994). Neither of these conditions exists in the action area. Egg incubation temperatures needed for survival have been shown to range from 2 to 4°C (Willamette National Forest 1989). Bull trout eggs require approximately 100 to 145 days to hatch, followed by an additional 65 to 90 days of yolk sac absorption during alevin incubation. Thus, in-gravel incubation spans 6 months or more. Hatching occurs in winter or late spring and fry emergence occurs from early April through May (Rieman and McIntyre 1993).

Generally, for their first 1 to 2 years, bull trout juveniles rear near their natal tributary and exhibit a preference for cool water temperatures (Bjornn 1991), although they appear less restricted by temperature than spawners. Newly emerged bull trout fry are often found in shallow, backwater areas of streams that contain woody debris refugia. Later and in habitats lacking woody debris, fry are bottom dwellers, and may occupy interstitial spaces in the streambed (Brown 1992). Since no known spawning occurs in the lower Duwamish River sub-basin, these habitat requirements are not pertinent to the proposed project.

Resident forms of bull trout spend their entire lives in small streams, while migratory forms live in tributary streams for several years before migrating to larger rivers (fluvial form) or lakes (adfluvial form). Migratory individuals typically move downstream in the summer and often congregate in large, low-velocity pools to feed (Bjornn 1991). Anadromous bull trout usually remain in freshwater 2 or 3 years before migrating to salt water in spring (Wydoski and Whitney 1979).

Bull trout life histories are plastic (i.e., variable and changeable between generations), and juveniles may develop a life history strategy that differs from their parents. The shift between resident and migratory life forms may depend on environmental conditions. For example, resident forms may increase within a population when survival of migratory forms is low (Rieman and McIntyre 1993). Char are generally longer-lived than salmon, and bull trout up to 12 years old have been identified in Washington (Brown 1992).

ATTACHMENT B

Project Area Photos

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Exhibit B-1. Pier 48 - Colman Dock

Exhibit B-2. Type A Seawall Pier 59

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Exhibit B-3. Type B Seawall

Exhibit B-4. High Riprap Bell Harbor

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Exhibit B-5. North End of Seawall

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ATTACHMENT C

Environmental Baseline Checklist

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CHECKLIST FOR DOCUMENTING ENVIRONMENTAL BASELINE AND EFFECTS OF PROPOSED ACTION(S) ON RELEVANT INDICATORS

Pathways: Indicators	ENVIRONMENTAL BASELINE			EFFECTS OF THE ACTION(S)		
	Properly[1] Functioning	At Risk[1]	Not Properly[1] Functioning	Restore[2]	Maintain[3]	Degrade[4]
Salmonid Sub-population Characteristics						
Sub-population Size			X		X	
Growth and Survival			X		X	
Life History Diversity and Isolation			X		X	
Persistence and Genetic Integrity			X		X	
Water Quality:						
Temperature			X		X	
Sediment			X		X	
Water Quality/Nutrients			X		X	
Habitat Access:						
Physical Barriers	X				X	
Habitat Elements:						
Substrate			X		X	
Large Woody Debris			X		X	
Pool Frequency			X		X	
Pool Quality		X			X	
Off-channel Habitat			X		X	
Refugia			X		X	
Channel Condition and Dynamics:						
Width/Depth Ratio			X		X	
Streambank Condition			X		X	
Floodplain Connectivity			X		X	
Flow/Hydrology:						
Peak/Base Flows			X		X	
Drainage Network Increase			X		X	
Watershed Conditions:						
% Total Imperv. Surface			X		X	
Disturbance History			X		X	
Riparian Reserves			X		X	
Species and Habitat:						
Integration of Sp. and Habitat Cond.			X		X	

Watershed Name: Duwamish River **Location:** Township 24N, Range 4E, Section 32

[1] These three categories of function ("properly functioning," "at risk," and "not properly functioning") are defined for each indicator in the "Matrix of Pathways and Indicators" (Table 1 on p.10) of NMFS, August 1996 (Making ESA Determinations of Effect for Individual or Grouped Actions at the Watershed Scale).

[2] For the purposes of this checklist, "restore" means to change the function of an "at risk" indicator to "properly functioning" (i.e., it does not apply to "properly functioning" indicators).

[3] For the purposes of this checklist, "maintain" means that the function of an indicator does not change (i.e., it applies to all indicators regardless of functional level).

[4] For the purposes of this checklist, "degrade" means to change the function of an indicator for the worse (i.e., it applies to all indicators regardless of functional level). In some cases, a "not properly functioning" indicator may be further worsened, and this should be noted.

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ATTACHMENT D

Habitat Restoration Opportunities Memorandum

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To: David Mattern April 25, 2003

From: Don Weitkamp, Parametrix, Inc. 554 1585 025 06 065
Bob Donnely, NOAA Fisheries
Kurt Buchanan, Washington State Dept. Fish and Game

RE: **SEATTLE SHORELINE HABITAT RESTORATION OPPORTUNITIES**

Modification of Elliott Bay's Seattle Waterfront has resulted in the total elimination of natural habitat characteristics along the shoreline extending from the mouth of the Duwamish River to the north side of the bay. Filling of intertidal beaches together with construction of the seawall and piers has resulted in steep hard substrate from above high tide elevations to shallow subtidal elevations. This absence of natural slopes and substrates over several miles of shoreline provides a need and an opportunity to restore natural habitat functions to an urban shoreline of considerable value to the anadromous salmonid and other biological resources of WRIA 9 and migrants from other areas. Restoration of natural habitat characteristics to a portion of this area could be provided as part of mitigation for the Alaskan Way Viaduct and Seawall Replacement Project or included as enhancement to improve the existing natural habitat conditions. The described habitat restoration opportunities are conceptual options and are not specific proposals.

There are a number of open areas along the existing waterfront where the shoreline is not committed to commercial uses. These open areas offer limited but substantial opportunities to restore natural habitat functions. The following is a brief summary of habitat restoration opportunities identified as part of the Alaskan Way Viaduct environmental evaluation. The approach is to identify habitat restoration opportunities that can restore some of the shallow water functions needed by young salmon as they migrate along the Seattle waterfront. Because of the substantial length of shoreline involved, it is desirable to develop several habitat restoration actions that would help to restore a connected corridor.

Intertidal habitat along the Seattle waterfront is important because juvenile chinook and chum salmon of the size (50-100 mm) that migrate along the Seattle waterfront from the Green/Duwamish River have specific habitat preferences that are not met by existing waterfront characteristics. These juveniles commonly remain in close proximity to shoreline structures (beach, bulkheads, piers, etc.) and within 1-2 m of the water surface. The fish appear to prefer gently sloping mud-cobble beaches. They commonly prey on epibenthic crustaceans during their rearing migration along this shallow water habitat. Thus, particularly when feeding at the bottom in shallow water they are susceptible to the forces of substantial waves and appear to avoid areas of either substantial wave or current energy. Therefore, we propose mitigation habitat attempt to reproduce both the shallow water characteristics apparently preferred by small juveniles and the sheltered conditions that make this habitat more functional for their needs.

The habitat restoration options described below were developed for publicly owned lands, but generally without knowledge of plans for other potential uses that may have identified for these sites. Available information indicates the sites are owned by the City of Seattle, the Port of Seattle, and/or the Washington State Department of Natural Resources. The habitat restoration options are presented in geographical order from the south end of the seawall to the north end of Elliott Bay and then the two options that are west of the seawall at the southern end of Elliott Bay. These habitat restoration opportunities are presented as options; they are not presented as a specific plan nor prioritized in any manner. General locations of the identified habitat restoration opportunities are shown on Exhibit D-1.

PIER 48

Objective

Develop an intertidal beach complex that is protected by an arch shaped extension roughly following the Pier 48 alignment or possibly other alignment with redevelopment of Colman Dock.

Concept

Remove the existing Pier 48 structure. Construct new beach and extend middle and lower intertidal portions offshore to outer edge of existing Pier 48. Include available portions of area between Pier 46 and Colman Dock. Curve beach to south at outer end to provide protection for Elliott Bay waves. Extend beach from shoreline edge of Pier 46 to south edge of reconstructed/relocated Colman Dock. Use clean excavated soil from tunnel construction or other sources to build beach. The surface layer of the beach would be sandy gravel in protected areas, with cobble to boulder size substrate on the surface of the more exposed areas.

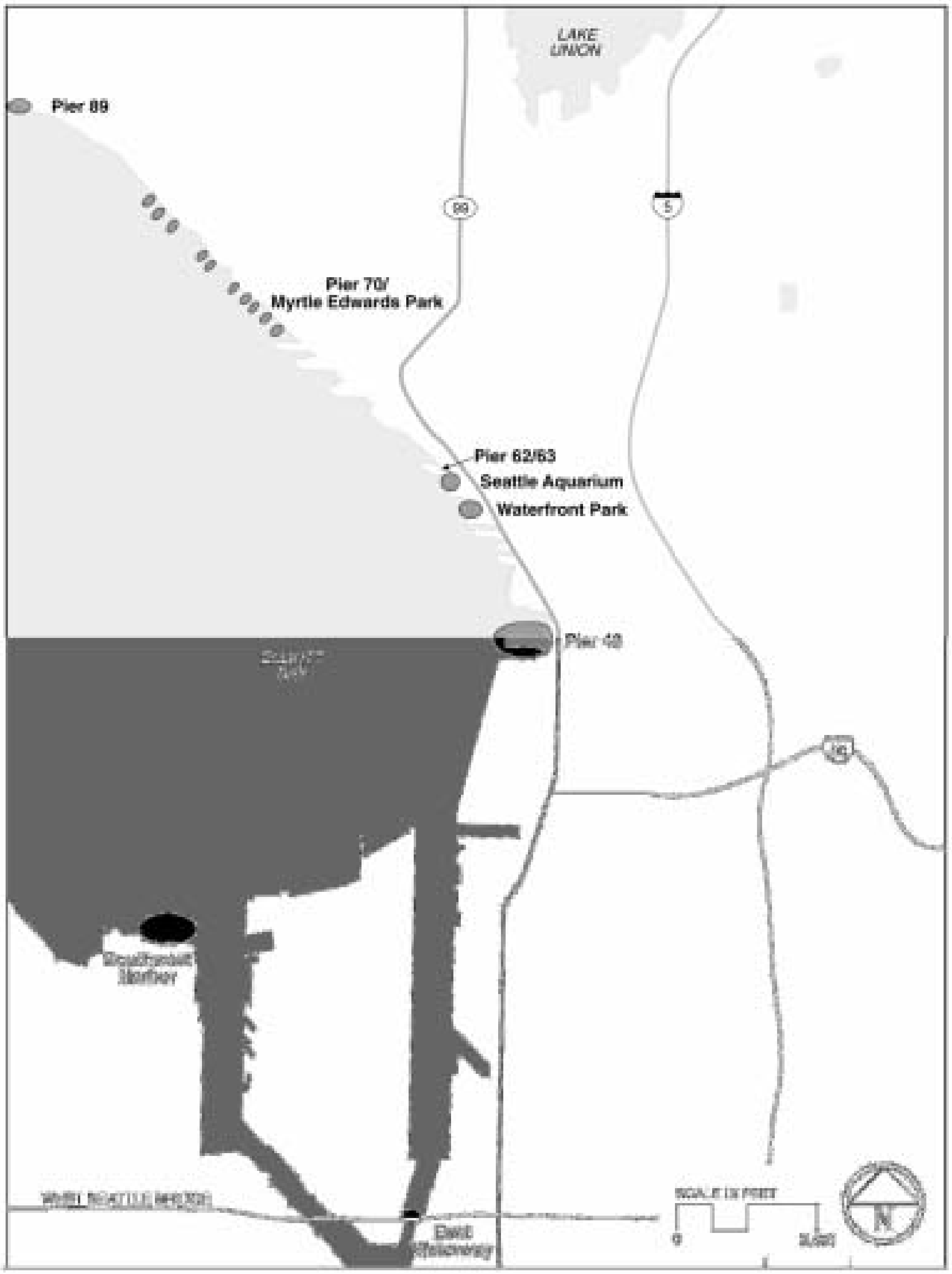

Exhibit D-1. Locations of Identified Potential Habitat Restoration Options.

If the site is used for transfer of construction materials, construct a steel pile supported narrow pier along the north side of the beach for transfer of construction supplies and excavated soil. Extend walkway over beach to floats for Washington St. moorage in small cove at southern edge of revised Colman Dock.

Alternative: design relocated Colman Dock to incorporate new beach along south side between dock and Pier 46.

If groundwater or stormwater source can be provided, add a small stream discharging across shoreward portion of the beach.

Benefit

Add a substantial quantity of protected intertidal and shallow subtidal habitat with fine grain sediment at the mouth of the East Waterway within a short distance of the mouth of the West Waterway. Most young salmon migrating out of the Duwamish River are likely to follow the general surface circulation in Elliott Bay that moves counterclockwise along the Seattle Waterfront.

WATERFRONT PARK

Objective

Develop an intertidal beach along the area immediately adjacent to the Waterfront Park pier.

Concept

The open area at the Waterfront Park site together with the moderate slopes of the shallow subtidal area offer an opportunity to develop a narrow intertidal beach immediately adjacent to and under the outer edge of the park's pier. The survey by divers indicated a rich algal community occurs in shallow water at this location. This production together with the limited protection provided by Pier 57 indicates that site has potential for productive intertidal habitat.

Although the Waterfront Park is constructed on a pier, there is relatively shallow protected water along its face between Pier 57 and the Seattle Aquarium. It is potentially feasible to construct a fill in this area that extends from about -60 ft MLLW up to intertidal elevations. The face of the fill would be at a slope in range of 2:1 to 3:1 (horizontal:vertical) and protected by rock. The beach would be at a slope of about 6:1 to 8:1 within the intertidal elevations of about -2 to +6 MLLW. The beach would have a surface substrate of sand, gravel, and cobble size material.

Benefit

Provide a small amount of moderately sloped intertidal and shallow subtidal habitat with fine grain sediment along the Seattle waterfront migratory corridor for young salmon, at a relatively protected location.

SEATTLE AQUARIUM

Objective

Develop an intertidal beach along the shoreline between the Seattle Aquarium and
Pier 63.

Concept

There is relatively shallow area of protected water immediately north of the Seattle Aquarium Pier that provides an opportunity for intertidal habitat restoration. The diver survey of this area also indicated a rich algal community occurs in shallow water at this location. This production together with the limited protection provided by Aquarium pier indicates that site has potential for productive intertidal habitat.

It appears feasible to construct a fill in this area that extends from about -60 ft MLLW up to intertidal elevations. The face of the fill would be at a slope of 2:1 to 3:1 and protected by rock. The beach would be at a slope of about 8:1 within the intertidal elevations of about -2 to +6 MLLW. The beach would have a surface substrate of sand, gravel, and cobble size material.

Benefit

Provide a small amount of moderately sloped intertidal and shallow subtidal habitat with fine grain sediment along the Seattle waterfront migratory corridor for young salmon, at a relatively protected location.

PIER 62/63

Objective

Develop new intertidal beach habitat along most of the shoreline portion of the piers.

Concept

Remove existing piles and decking along most of seawall to expose the shoreline, leaving only a narrow (<25 ft) access connection to the piers. Develop an intertidal beach between the remaining pier and seawall. The piers appear to have remaining shallow water substrate or fill extending a short distance offshore that could be filled slightly along the shoreline to produce an intertidal beach under the new opening. The surface of the intertidal beach could be a mix of sand and gravel with wave protection provided by the remaining portion of the piers.

Benefit

Increase the shoreline corridor inside a pier while providing a small amount of moderately sloped intertidal and shallow subtidal habitat with fine grain sediment along the Seattle waterfront migratory corridor for young salmon, at a relatively protected location.

PIER 70 / MYRTLE EDWARDS PARK SHORELINE

Objective

Produce new protected intertidal habitat along a substantial length of shoreline north of Pier 70 where it will not conflict with existing shoreline uses. Employ a detached offshore breakwater concept to protect shoreline habitat from wind waves and vessel wakes that commonly reach this shoreline with considerable force.

Concept

The exposed area of Elliott Bay north of Pier 70 extends to Pier 89 with either vertical seawall or steep riprap shoreline, except for a small beach constructed north of the Denny Way CSO outfall. This area commonly receives considerable wave energy from westerly and southwesterly winds and vessel wakes. Providing new protected intertidal habitat in this area would substantially improve the connectivity of the Duwamish River estuary with the north side of Elliott Bay. Pier 70 provides some wave protection to a small portion of the seawall. Additional breakwater type protection with shoreward habitat would provide new habitat supporting rearing functions for young salmon and other fish.

Gently sloping fine grain intertidal habitat would be constructed between the breakwater and the existing shoreline.

The breakwater would approach the shoreline at its southeastern end providing a narrow channel opening for fish with protection from waves. If placed in the lee of Pier 70 the opening can be moderately wide. Most waves approach the shoreline from the south through the west. The detached breakwater would be steeply sloped (2:1) on the offshore side and gently sloped (5-8:1) on the nearshore side.

Benefit

Add a substantial quantity of protected intertidal and shallow subtidal habitat with fine grain sediment along the northeastern end of Elliott Bay where a long reach of steep hardened shoreline currently exists in the highest wave climate portion of the bay.

PIER 89

Objective

Enhance the existing intertidal habitat along the eastern side of the waterway between Pier 90 and 89 (fill rather than a pile supported pier).

Concept

The shoreline of the Pier 89 area has about 2,000 ft of existing, gently sloping intertidal beach of an apparently natural character. The intertidal area has substantial man-made debris that could be removed. The outer or southern portion of the beach is highly exposed to wave action from the west-southwest. Protection of the southern portion of the intertidal beach from wave action would enhance the rearing function of a large portion of the existing intertidal area for juvenile salmon and other estuarine fishes. Constructing a berm-like beach extension at the southern end with rock protection on its southern face would provide increased wave protection resulting in a cove type habitat that is likely to provide improved rearing habitat for young fish.

Benefit

Provide protection from wave and current energy to a substantial portion of natural beach at the northeast corner of Elliott Bay. Remove man-made debris and creosote treated piles from the gently sloping fine grain beach.

SOUTHWEST HARBOR INTERTIDAL HABITAT

The 1994 design of the Southwest Harbor Cleanup and Redevelopment Project by the Port of Seattle included consideration of a sediment disposal and habitat restoration site in the shallow subtidal portion of the site at the mouth of the Duwamish West Waterway. The project included consideration of a consolidated sediment and habitat restoration over a shallow subtidal area of nearly 20 acres. The site of former Lockheed Shipyard piers could provide new intertidal and shallow subtidal rearing habitat for juvenile salmonids at the mouth of the Duwamish West Waterway where none only steep exposed shorelines and piers currently exist.

The concept is to place contaminated sediment in a facility behind a berm constructed offshore at about 40-60 ft MLLW. Contaminated sediment would be retained at lower intertidal and shallow subtidal elevations. Contaminated sediment would be covered with a clean sediment cap to provide contaminant isolation and shallow water habitat. The offshore berm would rise to upper intertidal elevations to provide protection of the habitat/cap and an offshore beach. A lower intertidal channel would be constructed across the habitat/cap to provide fish access during low tide conditions.

This concept would require cooperation of the Port of Seattle, Washington Department of Natural Resources, USEPA, and other entities involved in sediment cleanup in the Harbor Island-Duwamish River area.

INTERTIDAL PANEL HABITAT

Objective

Reconstruct moderately sloped intertidal habitat where shoreline fill is not feasible.

Concept

Some or all of the City of Seattle seawall replacement may not allow development of a fill providing sloping intertidal habitat. Since sloping intertidal habitat is likely to be a high priority for resource agencies involved in permitting the project, it is desirable to explore opportunities to provide the essential habitat characteristics in the absence of a major fill.

Install precast concrete panels with a combined pile-seawall support system at a slope in the range of 5:1 to 8:1 along the face of the Seattle seawall and the edge of piers. Use existing technology to provide panels that can be field-tested in the immediate future. Add roughness features to the upper surface in the form of ridges and gravel-cobbles that provide natural characteristics of beaches. Ridges perpendicular to the slope will provide a means to trap fine sediment settling from the water column. The moderately sloped hard substrate would provide a hard surface on which diatoms and algae would grow that form the base of the food web supporting juvenile salmonids and young of other fishes during their shoreline rearing periods.

Benefit

Add moderately sloped intertidal habitat along seawall and/or pier locations where shoreline fill is not practical.

Background

Previously we have explored habitat restoration alternatives along the face of piers as part of the Southwest Harbor Project conducted for the Port of Seattle along the East Waterway of the Duwamish River. One of the concepts we explored was development of sloping intertidal habitat in the form of precast concrete panels that could be incorporated into the face of a pier or vertical bulkhead. Development of a major fill option at the Elliott Bay face of the Southwest Harbor site provided an opportunity to construct intertidal habitat at an alternative location. Thus, the intertidal panel concept became unnecessary and was not fully developed as an intertidal habitat alternative.

Structure

Precast concrete panels will be developed for installation on the face of the seawall and perhaps edges of piers to provide a hard sloping substrate within the intertidal zone at depths most beneficial to young salmon. The precast panels will be supported by steel or concrete piles and possibly the face of the seawall.

EAST WATERWAY HABITAT

Objective

Constructed complex intertidal habitat in a protected portion of the East Waterway where it will not conflict with existing waterway uses.

Concept

The East Waterway of the Duwamish River is the lesser of the two river channels through the estuary. However, it most likely is the migratory route for a portion of the juvenile salmon produced in the Green-Duwamish River system. There is very little intertidal habitat providing natural functions along the East Waterway. Construction of new intertidal habitat would support those young salmon migrating through the waterway or entering from Elliott Bay.

The head of the East Waterway of the Duwamish River underneath the West Seattle Bridge is an area that has no existing shoreline use, making it potentially available for intertidal habitat. Navigational use of the area is restricted to small boats by the low level Spokane Street Bridge just north of the high-level freeway bridge.

Benefit

Add intertidal habitat to a protected location along the migratory corridor of a portion of the fish passing through the Duwamish estuary at a location unlikely to be used for other purposes.

FRESHWATER SOURCE

A number of the intertidal beach restoration options, such as Pier 48, Seattle Aquarium, Pier 70/Myrtle Edwards Park, etc., would benefit from a clean freshwater source to produce a small stream flowing across the intertidal habitat. The source would provide freshwater for waterfowl and potentially reduce salinity of the beach soils to allow growth of estuarine vegetation. A freshwater stream might also attract more young salmon and other estuarine fishes to the site.

The source of the freshwater would potentially be ground water collected landward of the seawall or AWV structure, or stormwater collected through reconstructed drainage. Treated stormwater would potentially provide a sufficiently clean source of freshwater to provide habitat benefits.

REUSE OF DEMOLITION/DREDGE MATERIALS

The project concept for the Pier 70/Myrtle Edwards Park area envisions an offshore component to reduce wave energy. This intertidal berm or breakwater structure would need to be structurally sound. Potentially it could be constructed from large concrete remnants from removal of the existing Alaskan Way Seawall, the Alaskan Way Viaduct, rebuild of the SR 520 Lake Washington Bridge, or other sources. The pontoons from the Lake Washington Bridge could potentially serve either as floating breakwater structures to protect constructed intertidal habitat form extreme wave energy at the Pier 70/Myrtle Edwards Park or Pier 89 sites, or as part of rubble breakwater structures. Clean soil removed from the Alaskan Way Viaduct replacement and/or dredged from the Duwamish turning basin could provide material for construction of the intertidal habitats at any of the locations.